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ABSTRACT

This Congressional report deals with the role of government laboratories in regional development and state innovation strategies for encouraging entrepreneurship. Included among those persons providing testimony on these two particular aspects of developing entrepreneurship in the United States were representatives of the following agencies and organizations: the U.S. Department of Commerce, the U.S. Army Construction Engineering Research Laboratory, Sandia National Laboratories, the Lawrence Livermore National Laboratory at the University of California, the University of Florida, the Microelectronics Center of North Carolina, Brennan and Garson, Control Data Corporation, and the U.S. Small Business Administration. (MN)

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CLIMATE FOR ENTREPRENEURSHIP AND INNOVATION IN THE UNITED STATES

HEARINGS

BEFORE THE

JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

NINETY-EIGHTH CONGRESS

SECOND SESSION

PART 1

AUGUST 7, 1984—ROLE OF GOVERNMENT LABS IN REGIONAL DEVELOPMENT

AUGUST 9, 1984—STATE INNOVATION STRATEGIES

Printed for the use of the Joint Economic Committee

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ROLE OF GOVERNMENT LABS IN REGIONAL DEVELOPMENT

TUESDAY, AUGUST 7, 1984

Congress of the United States,
Joint Economic Committee,
Washington, DC.

The committee met, pursuant to notice, at 9:30 a.m., in room 1310, Longworth House Office Building, Hon. Daniel E. Lungren (member of the committee) presiding.

Present: Representative Lungren.

Also present: Robert Premus, professional staff member.

OPENING STATEMENT OF REPRESENTATIVE LUNGREN, PRESIDING

Representative Lungren. Good morning.

Research in Government laboratories provides an important source of new ideas for the economy. These new ideas have enormous potential to spur entrepreneurial activities throughout the Nation and in the regions where the labs are located. Many regions, realizing this potential, are beginning to emphasize technology transfer in their development strategies. The Stevenson-Wydler Act, by requiring Government agencies and labs to transfer technology and disseminate information about the commercial potential of their research, is aiding this process.

The hearing today will explore the technology transfer issue from the perspective of Government laboratories. The committee is particularly interested in possible barriers to entrepreneurial spinoff activity from Government-funded research, and the type of environment within Government labs that is most conducive to technology transfer. Patent policies, licensing procedures, responsibility for technology transfer, and joint venturing are topics that will be discussed.

The central question concerning America today is how to encourage technological innovation so our economy can compete. The improved flow of technology from Government research can be an important component of this national innovation policy. Finding ways to improve technology transfer without sacrificing the mission requirements of Federal agencies is the major focus of this hearing.

I am pleased to announce that we have appearing today a group of nationally recognized experts and practitioners on these issues. Mr. Clarence Brown is Deputy Secretary of the Department of Commerce, a former Member of Congress and a former ranking Republican member of the Joint Economic Committee. Mr. Brown, we are delighted at your appearance before the committee today, and we are looking forward to your testimony. Other witnesses include Colonel Paul Theuer, U.S. Army Construction Engineering Research Laboratory; Mr. George Dacey, Sandia National Laboratories; Mr. Charles Miller, Lawrence Livermore National Laboratory; and Mr. Edward Malecki, University of Florida.

Gentlemen, we welcome you to the hearing and look forward to your testimony.

First of all, we will hear from a former colleague, someone who helped me when I first came to Congress, Mr. Clarence Brown.

STATEMENT OF CLARENCE BROWN, DEPUTY SECRETARY, DEPARTMENT OF COMMERCE

Mr. BROWN. Good morning, Congressman. I am delighted to have a chance to meet with you this morning and with this historic and significant committee which I served on for 13 years while I was in Congress, and discuss the role that Government laboratories could play in regional economic development. Because of the Commerce Department's Governmentwide responsibilities for technology transfer and patent policy, I want to address the Federal laboratory system as a whole in my remarks this morning.

The U.S. Government owns and operates—or has contractors operate—nearly 400 laboratories. These labs employ from 10 to over 5,000 employees, a total of over 200,000 people, 83,000 of whom are full-time professional scientists and researchers. We are the single largest employer of that class. The labs spend about one-third of the Federal research and development budget or about one-sixth of all the R&D funds spent in the United States.

Although the labs are part of a rich tradition of Federal scientific activity dating back to the earliest days of our country, most of the labs are relatively isolated from the private sector. This isolation problem has been addressed in several reports, including the May 1983 Report of the White House Science Council's Federal Laboratory Review Panel, also known as the Packard Report.

Last February, the Department of Commerce issued a report on the Government's accomplishments under the Stevenson-Wydler Technology Innovation Act of 1980. The report commends the Federal agencies for doing a valuable job of providing information, advice and technical assistance to State and local governments and to the private sector. The report points out, however, that the agencies are not doing nearly as well when it comes to using their inventions as a basis for technology transfer and collaboration with private industry, largely due to a lack of decentralized authorities and incentives. Other recent reports present the same conclusions.

Several years ago, Congress passed a law—the Dole-Bayh Act—which permits small businesses and nonprofit organizations—that is universities—to own inventions that result from Federal R&D funding. Under earlier policies, the Government took title to most inventions it had funded, then for a variety of reasons did little if anything to promote the commercial use of those inventions. The new Dole-Bayh law allows universities to own inventions they produce with Government funds and to pay a share of royalties to the inventors, frequently professors and even students. As a result of these incentives, nearly all universities with significant research programs are now marketing their inventions.

As the universities began to promote inventions, they found that potential licensees were often interested in contributing to the future projects of the university, faculty, or the inventors themselves. For many universities, this raised serious ethical issues ranging from conflicts of interest to freedoms of inquiry and publication.

By and large, the universities have resolved these issues, and are receiving ever-increasing amounts of private sector support related to the inventive results of the Government funded research they have done. The new law provided the four ingredients most necessary for encouraging successful transfers of inventions to industry:

One. An incentive for an inventor to report an invention and participate in its future development for commercial use.

Two. An incentive for a university to patent and promote commercial use of a federally funded invention.

Three. An incentive for a firm to invest in an invention derived from federally funded research because of the protection provided by a university license.

Four. Authorities for a university to negotiate a license and the follow-on collaboration necessary to increase the chances that commercial use will be a success.

The Federal laboratories are much like universities. Since they can produce no products, their inventions must be transferred to industrial concerns if the public or the inventor is to benefit in any way. But the need for a Federal lab to transfer technology is no assurance that the innovation will occur. The fact that a Federal lab is involved is often a serious barrier to innovation.

At a minimum, a successful innovation requires a problem in need of a solution; an invention that solves the problem; an effective advocate of the invention; the necessary investment for development, production, and marketing; and the management skills to put them all together. The innovation chain works best when all the links are within a single private company and there is no transfer at all and everybody has their job to do in the process. The problem of transferring technology from a university or a Federal laboratory to the private sector is difficult primarily because it involves links between parties that are not accustomed to working together in the same way, frequently don't even speak the same language.

Universities have found that the innovation chain cannot work for their inventions unless they strive to make all links work as well as possible. This often includes collaboration of the inventor or the university laboratory directly with commercial firms in further development. That's the concept for many universities and also the concept in some cases for the private sector.

The best way to get more new technological products for regional economic development, national growth and international competitiveness we need out of the dollars spent on the Federal labs is to open their doors to collaboration with the private sector.

In the Washington area, the National Bureau of Standards, Montgomery County, MD, and the University of Maryland have recently embarked on a joint effort called the Center for Advanced

Research in Biotechnology. The center is designed to meet the separate objectives of all the participants more effectively than would be possible by the parties working alone. The benefits—regional and national economic development, improved education and training, and better service by a Federal laboratory—will all be made possible through collaboration.

The Department of Commerce has recently announced it is now allowing proprietary work and joint research to be conducted by American firms in its National Bureau of Standards facilities. For example, we are currently underway on equipping the NBS reactor out at Gaithersburg with a cold neutron source, one of three planned in the world. The French have one, and the Japanese are investing heavily in one. Ports on the source would be made available to other researchers including commercial firms on a full cost recovery basis with compensation for the Federal employees.

Most Federal agencies do not believe they have the authority to let their laboratories enter into such arrangements, or they fear reactions if they do. I must confess we had some second thoughts ourselves. The National Bureau of Standards is unusual in that it has the authorities it needs to enter into most of the types of joint arrangements that are desirable.

Some other Federal laboratories recognize the problem and are asking for decentralized authorities they do not have. Even in the Department of Defense there are labs that could benefit the public by involving industry in the development of products that have both civilian and military applications. They see that this could spread the development cost, reduce it for the Government. It could also lead to more commercial products being made available to meet DOD procurement requirements off the shelf, and generally improve the process of getting the invention into private hands.

This is where regional economic development comes in. Many States and localities are developing high-tech research and industrial parks. For new businesses and jobs to be created, much of the technological base will have to come from the Federal labs. This requires allowing the laboratories to deal directly with business firms in their geographic area or with firms that are interested in the labs' fields of research.

Let me just conclude by citing a specific example out in my own State of Ohio in the area that I used to represent in the Congress.

Wright Patterson Air Force Base has many of the more sophisticated laboratories of the Air Force Systems Command, the command that develops weapons and avionic systems and so forth.

In the university community in the area and with the cooperation of one of the communities and townships and one of the counties near Wright Patterson they are developing an industrial park which will be used as a research center for spinoff of things discovered at Wright Patterson Air Force Base.

Recently when the Canadian airliner caught fire because of apparently some problem in the lavoratory of the plane, whether it was induced by mechanical failure or a passenger smoking in the lavoratory I'm not sure, but when that plane caught fire in the air and was forced to an emergency landing and there was some loss of life and injury, it occurred to me to wonder whether some material that had been produced by the materials lab of the Air Force Systems Command out at Wright Patterson had ever been transferred to private usage. That was flame-retardant material which is used in military aircraft and I must say that to this day I'm not sure that that process ever benefited adequately the private airplane sector. But it is a good example of the kind of thing that can be accomplished by opening up laboratories to this kind of relationship with the private sector and we are going to try to see what we can do in Commerce to develop it in all of our laboratories.

[The prepared statement of Mr. Brown follows:]

PREPARED STATEMENT OF CLARENCE BROWN

I appreciate the chance to meet with you today to discuss the role Government laboratories could play in regional economic development. Because of the Commerce Department's Government-wide responsibilities for technology transfer and patent policy, I would like to discuss the Federal laboratory system as a whole. I believe that an overall view of what the laboratories might contribute by way of technology transfer and private sector collaboration should be useful to the Committee, especially in view of the labs' potential for increasing the country's international competitiveness. position.

The Government owns and operates nearly 400 laboratories. These labs range in size from 10 to more than 5000 employees. They employ over 150,000 people, some 60,000 of whom are full-time professional scientists or researchers. Many of these labs are pioneering in such fields as medicine, space, agriculture, weather, forestry, defense systems, safety, environmental sciences and basic research.

There are also more than 25 Government-owned laboratories run by contractors for the Department of Energy that employ an additional 62,500 people, nearly 23,000 of whom are professional scientists and researchers.

Together these labs spend about one third of the Federal research and development budget or about one sixth of all the R&D

funds spent in the United States. They are part of a rich tradition of Federal scientific activity that dates back to the early days of our country. Unfortunately, the tradition of most of the labs includes relative isolation from the private sector. This tradition of isolation must be broken if the laboratories are to make a significant contribution to regional economic development.

The problem of the isolation of Federal labs has been addressed in several recent reports. The May 1983 Report of the White House Science Council Federal Laboratory Review Panel (the Packard Report) Recommendation Number 5-2 states:

> R&D interactions between Federal laboratories and industry should be greatly increased by more exchange of knowledge and personnel, collaborative projects, and industry funding of laboratory work, provided an oversight mechanism is established to prevent unfair competitive practices.

The Department of Commerce was required, by Section 5 of the Stevenson-Wydler Technology Innovation Act, to submit a report to the President and Congress on the Government's activities and accomplishments under the Act. I include a copy of the report as an appendix to my testimony.

In brief, the report states that although the agencies are doing a creditable job of providing information, advice and technical assistance to State and local governments and the private sector, they are not doing nearly as well when it comes to using their patented inventions as a basis for technology transfer and collaboration with the industry. As I will explain, this is due, in large part, to a lack of decentralized authorities and incentives, complicated by the centralization of patent licensing activities.

There is precedent for doing what the Government has to do to increase private sector collaboration. Several years ago, acting on the example of the Department of Health, Education, and Welfare, Congress passed a law--the Dole Bayh Act--that allows small businesses and nonprofit organizations to own inventions that result from Federal R&D funding.

Under earlier policies, the Government usually took title to the inventions it had funded, then for a variety of reasons, did little if anything to promote their commercial use. The Dole-Bayh Act coincided with a general tightening of budgets, so universities were quick to recognize inventions as assets that could be licensed and converted into income. Nearly all of the universities with significant research programs established patent licensing offices to market their inventions.

The Act also required a portion of the royalties to be shared with the inventors. This incentive broadened the interest of university researchers from publication (which can sometimes destroy the patentability of an invention) to seeing that their ideas are actually commercialized.

Most of the universities established patent licensing offices which began contacting private industry to promote the universities' patented inventions. As these university-industry relationships developed, the universities found that potential licensees were often interested in the future work of the inventors. Sometimes this took the form of offers to support additional developmental work to prepare the invention for commercial use. At other times, potential licensees were interested in supporting research beyond that which had led to the invention.

For many universities, these offers appeared to create a serious dilemma. The idea of direct involvement of university faculty and facilities in commercial enterprises seemed to be a violation of traditional independent study. It was feared that private sector funds provided as a result of the profit motive might influence the direction and independence of researchers. Concerns existed about the conflict between private industry's desire for confidentiality to protect patentability and the academics' social interest in advancing knowledge and the personal desire to attain recognition--the "publish or perish" syndrome. Conflict of interest situations within faculties also presented concersn, as did priorities of student curricula versus industrial investment in the institution.

I am not diminishing the importance of these concerns when I say that the universities are finding ways to manage them. Policies developed to handle these concerns differ. But universities have generally concluded that there is nothing inherently incompatible with, on the one hand, accepting private sector funds from royalties on university patents or support for profit-motivated research, and, on the other hand, the training of scientists to meet society's needs. In some respects private funds bring less conflicts than Federal funds bring.

As the universities developed policies relating to the private sector, the private sector firms found the universities to be much more business-like in two respects that are vital to effective technology transfer. First, the university patent licensing officers (who have come to fulfill a much broader role) now negotiate from a better understanding of what the university can and cannot do. If a Government funded invention is involved, clear ownership of the patent allows the university to make agreements without the uncertainty and time loss of review by a Federal agency. This certainty is vital to successful negotiations.

Second, if continued research involvement by an inventor or the university laboratory in the innovation process is desired by the licensee, the universities are now willing to work out reasonable terms. In many cases, there is no substitute for the inventor's special knowledge, insights and dedication.

I don't mean that Federal patent policy can take all the credit for bringing academia and business into closer cooperation. For years, a few farsighted universities have pioneered the types of cooperation that have led to Silicon Valley, Route 128 and the Research Triangle. In some happy situations, there has been close cooperation between universities and industrial concerns for years. What the new Government patent policy did was help and prod all universities to use the results of Government funded research to promote the opportunities of industry collaboration.

The Federal patent policy of the Dole-Bayh Act provided the four ingredients most necessary for successful transfers of inventions to industry:

1. An incentive for an inventor to report an invention and participate in its future development for commercial use.

2. An incentive for a university to patent and promote commercial use of a Federally-funded invention.

3. An incentive for a private firm to invest in a Federally-funded invention based on the protection provided by a university license.

4. Clear authority for a university to negotiate a license and the follow-on collaboration necessary to increase the chances that commercial use will result.

The Federal laboratories are much like universities. Since they produce no products, their inventions must be transferred to industrial concerns if the public is to benefit from them.

The research and development programs of the laboratories and the inventions they produce fall largely into two broad categories: First, those to meet public needs in areas of commerce, agriculture, public health and safety and environmental protection; and second, those which have Federal responsibility for the defense and space programs.

In the first category, which includes such items as vaccines to prevent diseases, there is a ready market for inventions. Firms will compete for the right to produce and market such products. Relatively few Government laboratory inventions are in this category since a small portion of the Federal R&D budget is required to support this type of work. Improved governmental collaboration and cost sharing with industies and universities could allow Government laboratories to accomplish much more without increasing budgets.

Since the Government is frequently the sole buyer--or at least the primary purchaser--of end products using inventions in the second category, it is very difficult to establish a market value for the patents because commercial usage may be slow to develop if at all. In some cases, however, the inventions have private sector uses that can be exploited without detracting from their value to the Government. It is in the space and military areas where the commercial economy appears to be missing out on opportunities to benefit from some really important new developments.

Transferring inventions for which there is not an obvious and immediate market is sometimes a difficult matter in which the Government has not done well so far. The Department of Commerce runs a patent licensing program as a service for all agencies wishing to use it. So far, nearly all the inventions licensed by Commerce for private development have been the products of research to solve significant problems where there was an obvious waiting market.

Two conclusions are clear: Government is not as good a marketer as the private sector, and the world does not always beat a path to the door of an inventor of a better mousetrap.

Sometimes, the private sector is not alert to the significance of a new technology or not willing to use an invention that will improve or render obsolete their current product before the expected end of the product's useful life. Frequently, a company that develops and markets new products has access to more ideas than it has capacity to use. Such companies have established procedures to screen inventions and select the few in which they can afford to invest. Inventions often pass the screening process primarily because the advocate is inside the company--perhaps the inventor himself.

It is important to remember about the innovation process that invention is merely one of the first steps. The investment that led to the invention is typically about ten percent of the total investment that will ultimately be required to produce and market a successful product.

The problems of transferring technology can present serious barriers to innovation.

A successful innovation requires a problem in need of a solution, an invention to solve the problem, an effective advocate of the new idea, the wherewithall to finance investments in development, production and marketing and the management skills to put these parapetetic processes all together. Of course, the innovation chain works easiest when all the links are within a single company and there is no transfer at all. The problem of transferring technology from a university or a Federal laboratory is difficult primarily because the chain involves links between parties who are not accustomed to working together. The advocate sometimes does not even have the opportunity to communicate with those who must be convinced.

To gain more out of the dollars spent on Government labs, to achieve more regional economic development, and to produce more technological products for national economic growth and better international competition, we must open doors of more public institutions to collaboration with the private sector.

In the Washington area, the National Bureau of Standards, Montgomery County and the University of Maryland, have recently embarked on a collaborative venture in biotechnology. The new venture--called the Center for Advanced Research in Biotechnology--is designed to meet the separate objectives of the participants more efficiently and effectively than would be possible by the parties working alone.

In the partnership, the National Bureau of Standards gains easy access to biological experts and facilities through collaboration with universities and industry. Through this means, the National Bureau of Standards expands and diversifies its services to U.S. industry, and improves its technology transfer, all crucial to the development and commercialization of biotechnology in the Nation as a whole.

This venture will also give the University of Maryland the opportunity to extend its educational and training services to an area of public need and high potential, in an arrangement which will also give it improved access to experts in measurement and physical sciences who have ties to industry.

The benefits to be derived--regional and National economic development, improved education and training, better service by a Federal agency are all made possible through the pooling of resources and unique strengths.

As another example, the Department of Commerce has decided to allow proprietary work and joint R&D to be conducted by American firms in the National Bureau of Standards facilities.

NBS has unique facilities where proprietary work might be of interest to the private sector. For examplem, in the materials science area we are currently eviewing plans to equip the NBS reactor with a cold neutron source.

Ports on the cold neutron source would be made available to private firms for proprietary work in exchange for their equipping the ports and making one third of the time available to other researchers. A chance would also be provided for other firms to conduct proprietary experiments.

NASA and several DOE laboratories have also decided to allow use of their unique facilities by private industry for proprietary work, and we would encourage all Federal laboratories to make similar arrangements where it is possible.

For many laboratories, the main problem is the lack of decentralized authorities. Many governmental agencies do not believe they have the authority to delegate a technology management role to their labs, or they fear reactions if they do.

By technology management, I mean such responsibilities as negotiating patent licenses, entering into collaborative research agreements, assigning rights to inventions that may result from collaborative arrangements, and using royalties to reward inventors. The National Bureau of Standards is exceptional in that it has a tradition of private sector collaboration and it has the authorities it needs to enter into many of the types of collaborative arrangements we believe are desirable.

Some other laboratories recognize the authority problem and are seeking the decentralized authorities they do not have today. Even in the Department of Defense there are labs that want to involve industry in the development of products which have both civilian and military applications. They see that this could reduce development costs and lead to commercial products available off-the-shelf to meet DOD procurement requirements.

Here is where regional economic development comes in. Many States and localities are developing high-tech research and industrial parks. New businesses and jobs are being created at record rates. Much of the technological base for this growth has come from Federally funded research and development.

The growth is good, but the country needs more, particularly in some regions. The U.S. leads the world in the percent of Gross National Product that we spend on R&D. About half of the total is private; about half is funded by the Federal Government. Much of the Federal expenditure is in the defense and space areas. Many of our present industries are founded on technologies developed originally for military purposes. We must find ways to get the new technologies that have potential civilian uses out into the economy faster.

To do this, technology transfer must be made as simple and direct as possible to be compatible with the innovation process of the American economy. This means allowing the laboratories to deal directly with businesses, firms which are interested in their fields of research.

Representative **Lungren**. Thank you very much for your testimony.

In the last page of your summary testimony you say that most Federal agencies do not believe they have the authority to let their laboratories enter into such arrangements or they fear reactions if they do. Is it more a problem of perception or is it that we in Congress have not given them the authority that's necessary?

Mr. **Brown**. I think it's a problem of perception, but I think it would help if the authority were spelled out. When we undertook to open up the Bureau of Standards laboratories some months ago—and the process is not quite in action yet, but we have interest expressed and have our rules laid down for how we will function—we based it on the approach that NASA took and the legislative authority that they were given when they were created.

Not all the laboratories created by the Federal Government in its history have those same rights or authorities.

It seems to me that that ought to be spread through the Federal Government generally and the best way to do that is Federal legislation giving them that authority. But I think many laboratories, if they just look, will discover that they already have the right. It's just that habit and background have meant that they haven't done it because the laboratory may have been started for a specific single purpose and the idea of cooperation between the Federal laboratory and the private sector never occurred to them. Also, there are some conditions generally written in Federal law that need to be addressed also, where the Federal employee is not supposed to participate with the private sector in such effort.

Representative **Lungren**. Generally speaking, is the Stevenson-Wydler Act sufficient to allow most of these agencies to be cooperative?

Mr. **Brown**. Well, the Stevenson-Wydler Act certainly encourages it. I'm not sure that it solves all the problems that we have in the area, but it certainly is helpful in that regard and it makes it a matter of national policy and that, of course, motivates the Federal Government.

Representative **Lungren**. You have already mentioned that in your own former congressional district there was opportunity for some of this cooperation between Wright Patterson and others. As a general matter, in your opinion, is technology development for the military transferable to the private sector?

Mr. **Brown**. I think there's a lot that is. A list of some of the laboratories, for instance, that are in that area would include fuels and lubrication technology; as I mentioned, materials laboratory. They do work in ceramics. If we could solve the problem of the ceramic engine for automobiles and aviation, we might very quickly seize back leadership in the automobile industry. And there are other such laboratories that relate to the biomedical impacts of flight and even space activities on individuals. All these are areas that contribute to transferable knowledge that can be helpful both for commercial use and also for medical activity.

Representative **Lungren**. You mentioned that collaboration betw[illegible]he public and private institutions is necessary to improve t[illegible]ogy transfer. Can you give us some specifics as to the type of arrangements that might be necessary to carry out that cooperation?

Mr. **Brown**. Well, first, there is the need clearly stated by the Congress for authority to be granted at the laboratory level to arrange for these collaborative agreements with the private sector, including such things as patent licensing authority to be allowed at the laboratory level. That's usually not centralized in agency headquarters, and that means that the bureaucratic process tends to slow it up. Conflict of interest rules now prevent Government employees from contributing to commercial development of their inventions while employees remain in their jobs. It seems to me that ought to be clarified. Many people who have a long-time investment in Federal service don't want to leave it, but they also don't want to be denied the opportunity to benefit personally from their efforts and their inventions.

The narrow mission statements for laboratories often include pursuing commercial uses for technologies they create. Perhaps that commission should also be given to the Defense Department where obviously there are security issues involved. Such issues, of course, existed—at least were perceived to exist—when the space program began.

I think both the Bayh-Dole and the Stevenson-Wydler bills provide the opportunity for those incentives. Perhaps a restatement of them would help, in the legislative sense.

I understand there is legislation that's been introduced in the Senate which is under consideration, and it would move toward establishing policy and procedures throughout the Government in this regard that would be worthy of consideration.

Representative **Lungren**. As I understand it, the Dole-Bayh law gives title to those inventions with respect to small businesses not in the province of universities, therefore leaving out larger commercial concerns. There has been some legislation to extend this to all companies regardless of size, but to this point it hasn't moved very far here in the Congress.

Do you have any impression as to what the impact would be if in fact there were legislation on this.

Mr. **Brown**. Well, I must say that when we decided to open the Bureau of Standards laboratories for commercial use, some of us hoped that the use of the laboratories would be solicited by the "Little Sisters of the Poor" rather than some of the larger oil companies on the theory that the public relations involved would be more desirable. But the fact is that like the laboratories themselves historically financed by the Federal Government, some of the larger corporations are the ones most likely to have the problems to solve as well as the resources to put into the laboratories.

I don't see how you can easily draw the line between large businesses and small businesses. As a matter of fact, if you wander through the Government agencies and ask for a definition of small business, you will get a variety of definitions. So I think it's going to be a hard line to draw in this regard.

We made the decision in the Bureau of Standards that we are not going to limit availability to large or small, but rather on the basis of a normal contractual bid. We don't want somebody to tie up the laboratories indefinitely and prevent competition. So, in connection with the cold neutron reactor, we are building several bays so a number of private sector groups can work at the same time. And we don't draw a line between universities who may want to do pure research and the businesses that may want to do a specific kind of research for their particular need. We are going to do it on a full cost recovery basis so that there is no problem with anybody being given a subsidy by the use of the laboratory because it's paid for everything they want to use. Companies will be able to hire, in effect, the personnel who run the equipment at the Federal laboratory to do the work for them. That is, Federal employees will contribute their normal pay, and the personnel in the laboratory who is doing the work will leave the notes and his knowledge of the activity with the company and not necessarily transfer it to the laboratory itself, although that can be negotiated between laboratories depending on the kind of work they do.

The objective of the proprietary use of the Bureau of Standards laboratory is that the private sector institution, whether it is a eleemosynary institution or private institution, large or small, would be able to use the laboratory for its own proprietary research and ultimate development of an invention or patent to further advance the technical knowledge it already has.

The reason for that is the NBS laboratory is so unique. We think it is literally wrong at a time in which we have such intense competition between American interests and other national interests in the economic field, the trade field among others, to deny the use of that very sophisticated laboratory to our American competitors.

Representative LUNGREN. You mentioned earlier about regional laboratories and their cooperation with universities or businesses in their area. Are we in government generally going about it in such a way as to ensure that folks outside the regional area get a crack at it and an opportunity to know what's going on and have an opportunity to participate? Obviously there are finite resources and finite opportunities for participation as in many things that the Government gets involved in. There are those who are lucky enough to be selected and those who are not. Is there sufficient knowledge out there within the business community to know of these opportunities, at least to your satisfaction?

Mr. BROWN. NTS has that responsibility for the Federal Government and it is a Commerce Department activity, one of the many different organizations that are housed in the Commerce Department. They do it through a series of different things such as publications which help businesses locate what they need in the way of laboratories or in the way of facilities that are available in which they might be able to participate—both university and Federal facilities.

We need more work done in this area clearly, and one of the difficult things that the Federal Government has to do and doesn't always do very well is to relay information from the government to the private sector.

I am amused by an unrelated example of how effectively U.S.A. Today takes Census statistics and makes them interesting and colorful, and we don't do that. The Federal Government document that has those basic statistics looks about as interesting as the average telephone directory white pages, and the effort for us to be able to categorize things and do things is a continual effort within the Department. I'm trying to spark that up a little bit as a personal matter.

But, in addition, our need is to use the networks available in the private sector such as trade journals, trade publications, and the trade associations themselves. I am interested sometimes to find out that a trade association—where maybe a major firm in that trade association is using a government patent—is unaware of the process by which the transfer of information is made available. So there's a lot of work to be done in the area.

Representative **Lungren**. Is there anything we need to do in the Congress with respect to that or is that just getting the process further down the line?

Mr. **Brown**. I think hearings like this help, but the thing that the Congress could do is to look at further legislative enhancement of the legislation that's already been passed to be sure that the Federal laboratories themselves are now in the process.

What you did for the universities has been very helpful in this regard in the Bayh-Dole bill and also in the Stevenson-Wydler Act. Now we need a little boost for the Federal laboratories to be encouraged to do the same thing that the universities are doing and for their mother agencies, their host agencies, to give them the authority that they need to do that at the laboratory level.

Representative **Lungren**. You mentioned that one of the keys, if not the key, to successful laboratory-private sector collaboration is in the structuring of the deals to provide incentives for both parties.

Do you have some general thoughts for us on how those deals should be structured so we could encourage this type of collaboration in technology transfer without undercutting or subverting the mission orientation of the labs themselves?

Mr. **Brown**. The variety of deals depends literally on the laboratory and private sector interests, but there are some basic rules, I guess, or basic approaches.

First, the authority for the laboratory to enter into the arrangements is important. It ought to be given to them at their level rather than at the level of the agency headquarters as I indicated.

Second, it needs to include some private sector arrangements or clear understandings about how the private sector will make reimbursable use of the unique government facilities.

Third, the licensing of lab inventions to private firms has to be covered as the agency would like to have that done or limited—in the case of the Defense Department—on security issues. Lab cooperation with general partners of research and development limited partnerships to develop laboratory inventions ought to be authorized. Cooperation with State and local governments to develop high-technology programs certainly could be related to the laboratories, and could be an authority the laboratory would be given. This would allow laboratory employees to aid businesses in developing their inventions into commercial projects or products, and would assist those firms that are developing laboratory originated technology, or that are receiving incubator services from the university or a unit of government. This ought to be spelled out in the authorities or in the agreement that is made with the private sector.

There's a wide variety of possibilities that we could go on and on with. But I would just say that the broadest authority possible for the local laboratory would be what they need to develop the unique kind of relationships that they could have with the various private businesses that they would be working with.

Representative LUNGREN. I want to thank you for appearing and being sort of our kickoff witness in this series of hearings. As you know, we're trying to look into the question of entrepreneurship and innovation and not trying to be repetitious of anything other committees have done. One of the areas we wanted to focus on for one hearing is Government labs. I think that's something that a lot of us don't pay much attention to. Members of Congress have newsletters and send out a lot of information on a lot of different things, but I'm not sure many of us have ever sent out information to our constituents about the possibility of information and cooperation with Government labs. It's an area that I wasn't very aware of and we can raise the level of awareness of many of the members as well as people throughout the Government process. Maybe we will assist in that. It is a resource obviously that ought to be used in this whole area of innovation and one that has not been used to the extent possible, at least to this point.

Mr. BROWN. As a personal matter, I think we are living in a very exciting time. A lot of people are put off a little bit by what's going on, the heavy competition going on in the world and the technological development between our country and countries that lack the resources unlike our situation. The Japanese qualify perhaps in that regard, but also developing nations that have been considered to be pretty slow in development historically, like the Koreans and Taiwanese are now getting into technology development very rapidly. And for us to keep the leadership that we need, we need to use all the resources we have available to us, and we have some very fine resources in the Federal laboratories.

One of the problems is that historically the Federal labs have not been motivated or excited by the kind of competition that we now face in the world. That transference of excitement is done almost on a man-to-man or person-to-person basis. We think we get a lot of that done by the example of NBS, and we are going to work at it. I think we have got some of the folks at NBS excited about it, and we think we can excite some other people in some of the other Federal laboratories. We appreciate your help and interest in it.

Representative LUNGREN. Thank you very much for appearing.

Next we will have a panel of experts and ask them to come to the table; Mr. George Dacey, president, Sandia National Laboratories; Mr. Edward J. Malecki, associate professor, University of Florida; Mr. Charles Miller, Lawrence Livermore National Laboratory; and Col. Paul J. Theuer, commander, U.S. Army Construction Engineering Research Laboratory.

We'll just start from my left to right. Would each of you make a presentation of somewhere around 10 minutes and then we can go to questions and answers of the entire panel, and I certainly hope you don't all agree. I'd like to get some disagreement here and have you respond to one another's points of view. I have found it much more effective in hearings to have those who disagree to be on the same panel at the same time as opposed to me trying to remember what question I should have asked based on a comment that was made by one of you an hour or 2 hours before. So if we could start with Colonel Theuer and make a presentation of about 10 minutes and then we will go down the line and then go to questions and answers.

STATEMENT OF COL. PAUL J. THEUER, COMMANDER AND DIRECTOR, U.S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY [CERL], CHAMPAIGN, IL, ACCOMPANIED BY LOUIS R. SHAFFER, TECHNICAL DIRECTOR

Colonel THEUER. First of all, I'd like to introduce my technical director, Mr. Louis R. Shaffer, who's largely responsible for a lot of success our laboratory has had.

Good morning. I am Paul Theuer, commander and director of the U.S. Army Construction Engineering Research Laboratory located in Champaign, IL. We are an element of the Army Corps of Engineers. I am pleased to be able to describe the role of a Federal laboratory in regional economic development through technology transfer and I would welcome any questions you may have.

USA-CERL is one of four research laboratories in the Army Corps of Engineers. My mission at USA-CERL is to find the best ways to plan, design, build, operate, maintain and repair buildings for Army installations worldwide. To accomplish this task, USA-CERL must be an industry leader, advancing the state of the art in engineering architecture, and all building construction related professions, including management, economic and environmental sciences. My mission, by its very nature, lends itself readily to technology transfer and innovation within both the military system and the private sector. I plan to highlight several examples this morning that show how our research contributes not only to our military mission but also, through technology transfer under the authority of the Stevenson-Wydler Act of 1980, to the enhancement of the civilian sector technology base and to the creation of jobs in the economy.

The concept of technology transfer means different things to the public and private sectors. Within the military system, technology transfer means taking that extra step in the R&D process to assure that the R&D product gets into the hands of the military user. USA-CERL products include items of hardware, computer software and technical information and data. Each of these are transferred to the military user through commercialization or through building specifications controlled by the Army. Computer software technology or computer products are transferred through computer software centers. Both Government and private sector users alike have equal access to these centers.

Information or technical literature developed by the Defense Department and other Federal laboratories is made available through established information systems such as the defense technical information system and the national technical information system.

I believe that USA-CERL has been particularly successful in making Government developed technology available for public use.

For example, on May 25 of this year we issued the Army's first two licenses for patents held by the Corps of Engineers. One license was for a device called the weld quality monitor developed at USA-CERL at a cost of $500,000. This device describes the quality of a weld as the weld is being placed. When tested in prototype form on the assembly line for the M1 Abrams tank in Lima, Ohio, the weld quality monitor demonstrated quality control savings of $4,500 per tank. Savings for the M1 tanks projected for fiscal year 1985 procurement, some 600 in number, are estimated at $2.7 million. Comparable savings are possible for other military vehicles and systems as well as on pipelines and pressure-vessels in the private sector. As a result of an article which we submitted to a professional journal describing the weld quality monitor, we were contacted by National Standard Corp. of Niles, MI, which expressed interest in the development of the device. Our discussion with National Standard resulted in the issuance of a license which provides for a 5 percent royalty to the United States. While National Standard is still in the development stage of production, the license of the device will result in 50 additional jobs by National Standard and should result in significant sales revenues which would not have been possible were it not for the license arrangement between the Government and National Standard.

The second patent licensed by the Corps of Engineers on May 25 was the Ceranode; a small high technology device that prevents cathodic corrosion on buried pipelines, storage tanks, and waterfront structures. This device was licensed after publication in the Federal Register to APS Materials, Inc., in Dayton, OH, with whom we had been working on other anodes. The license will also generate a 5 percent royalty for the United States and will not only increase APS' work force from 30 employees to 142 in 1 year but also increase their sales by an estimated $8.5 million. That converted into royalties is $425,000 a year.

Thus, technology transfer not only results in reduced manufacturing and operating costs by users of these licensed devices, but also generates jobs in the private sector and royalties for the U.S. Treasury.

I'd like to cite, sir, from the Congressional Record of June 7, page E2694, comments by Congressman Dan Crane, our Congressman. It exemplifies the relationship we have with the legislative branch—the elected branch, at the governor level, Senator Percy's level, and also Congressman Dan Crane's level.

I quote:

> Both the Army and the people of the United States will benefit from these inventions. These benefits will come in the reduced cost of this nation's construction, the reduced cost of maintaining metal structures, and more structurally sound structures having a longer life.
>
> 'These licensing agreements are a good example of how the Department of the Army can work hand-in-hand with private industry for the betterment of the Nation. By manufacturing Army-developed technology, private industry can make those technologies available to both the Army and industry alike. In doing so, industry can create new jobs and help stabilize local economies. Continued support of Army research efforts—such as those going on at the Construction Engineering Research Laboratory—is truly an investment in America through defense.

In the computer software area, USA-CERL does considerable work in the development of systems to expedite time-consuming processes such as are required for the preparation of environmental impact assessments and statements; energy efficiency assessments; and facility management systems. One such system, called "Blast", enables the building designer to assess building design energy efficiency early in the design process. The system allows a designer to obtain extremely accurate data on building energy consumption by inputing the thermal values of building materials, the heat values of energy and light sources and the geometric structural orientation of the particular design under review. "Blast" is a system which can be used in virtually any building design undertaken by the Department of Defense or, for that matter, any builder in the private sector. This system has been judged by the National Bureau of Standards to be the "standard" for building energy analysis and is currently being used in 47 computer centers in the United States. These include such noted software firms as McDonnell Douglas; Control Data Corp.; and Boeing Computer Services. "Blast" is also widely used elsewhere in North America, Europe, and Africa.

The Stevenson-Wydler Act of 1980 authorizes and directs Federal agencies to make available federally funded technology developments to State and local governments, and to the private sector. One way we have done this at USA-CERL is through close ties with the university community, the Federal laboratory consortium, professional societies, and the private sector. For example, 36 percent of our $30 million program in fiscal year 1984 for research will be conducted by university personnel. This relationship not only helps us to do our job, but more importantly, provides us a valuable two-way source of technology, and a natural outreach in technology transfer. We have arrangements with no fewer than nine major universities across the United States and we are negotiating with others. The resources of our university connection is a natural outlet for technical information and data of our products. Among the professional societies, we have ties with major technical committees operating in and outside the United States. The exchange of information and visitors enables us to integrate U.S. and non-U.S. technologies to obtain the best of both worlds toward meeting Army requirements for forces stationed in the United States and throughout the world.

The bottom line in technology transfer, however, is getting full utilization of what the Government has developed in the labs. At USA-CERL, we are proud of our record of sharing federally funded technology within the spirit of the Stevenson-Wydler Act. As a consequence, the Nation as a whole has benefitted. We should bear in mind, however, that while Stevenson-Wydler provides authority, there also must be an incentive for the Government to transfer the technology to the private sector and for the private sector to accept the transfer. In my view, the best way to do this is to provide industry and the private sector with a vested interest in this technology and allow commercialization through the marketplace. This ultimately benefits the Army as well as the economy in general. After all, unless industry manufactures the item, be it a licensable patent or nonpatentable technology development, the Army and Defense Department cannot buy it. Furthermore, once the decision to manufacture a product is made, there are secondary effects such as jobs creation and the development of domestic markets which promote regional economic development. The transfer of computer software technology requires similar incentives. In technical information and data, it is a bit more difficult, but not impossible to provide incentives through the development of a private sector vested interest.

Once the technology has been developed there is a continuing need to provide service after the sale. At USA-CERL we have had success with the establishment of industry run strategic support centers for several of the larger software systems we have developed which provide access to both Government and private sectors and also provide employment opportunities for local economies.

I should point out that a Government laboratory, such as USA-CERL cannot do the task of transferring technology alone if regional economic development is to be achieved. We need to work with the States who themselves have begun to develop such organizations, often around the university base, to find available technologies in Government laboratories that are transportable to their respective States in support of local and regional economic development. The State of Illinois has at least one such activity in computer software established through a cooperative effort on the part of the governor's office and the State's university system. The State of Oklahoma also has a similar effort devoted toward hardware which employs a permanent staff that seeks out new technologies which can be applied toward regional economic development these may serve as models.

I might comment that we have had interaction with the State of Ohio, the State of Kentucky, and the State of North Carolina.

The ultimate objective of USA-CERL is to make technology available to the Army. Once this is done, there is an inherent spin-off to the private sector which in turn promotes economic development. While attempts have been made to find a "universal model," there simply is no single model. It takes a concerned effort, on a case-by-case basis, working with some understanding of the economic forces then acting, to promote technology transfer in any form. Lots of individual initiative is required. USA-CERL successes prove that point. While we have been largely successful, there are still opportunities to do more.

The relationship between the Government laboratory and industry-licensee has to be recognized as being fundamentally different from the classic-industry relationship. Rather, when we transfer technology we have a "joint venture" arrangement. Simply stated, if our venture-partner fails, we fail; if he fails we cannot procure the item; and if he fails, the royalty potential is diminished. This is an example of the Government's vested interest.

And finally, we must all recognize, as we at USA-CERL have come to appreciate, that the greatest ingredient required to make technology transfer work, be the beneficiary the Army, private industry, or an effort to promote and support regional economic development, is personal dedication of laboratory personnel. The environment to provide for fostering personal dedication is essential.

Thank you for your time and attention. I am prepared to answer any questions.

Representative LUNGREN. Thank you very much.

Mr. Dacey.

STATEMENT OF GEORGE DACEY, PRESIDENT, SANDIA NATIONAL LABORATORIES

Mr. DACEY. Thank you, Congressman.

I am pleased to be able to talk to the committee this morning since I think this is an enormously important topic. I want to put my remarks in context in that I believe Sandia National Laboratories is somewhat different than many of the other institutions you will be hearing from.

In the first place, we have a very definite mission. We design the nonnuclear parts of all nuclear weapons in the Nation's stockpile, and we are responsible for these parts from the earliest ideas through weapon retirement, including quality assurance. Therefore, we actually do design a product which has to be manufactured by several factories and for which we have the design responsibility.

We are also different in that we are primarily an engineering laboratory. We have a technical staff of 2,500 people, about half Ph.D. and half M.S., but mostly in engineering rather than in pure science, which most of the other laboratories tend to emphasize.

Another difference is that we are operated by the AT&T Co. under contract on the model of Bell Laboratories, so that we have an industrial pattern rather than an academic pattern such as exists in many other national laboratories operated by universities.

For all of those reasons, I believe the number of our technology transfers is substantially greater than most of the other laboratories because many of our things are closer to the marketplace when we finish with them.

The Stevenson-Wydler Act did not really change our technology transfer very much because it asked for a listing of technologies and required that we spend at least half a percent of our budget on technology transfer, which we were far exceeding already. So it really didn't make much difference to us.

Since we have been counting for Stevenson-Wydler, we have transferred 226 technologies to over 300 companies. To give you some examples of these technologies, one of the oldest is the clean room which we use to make very highly reliable parts for nuclear weapons, but which is now the basis for the semiconductor clean room industry used in making silicon chips. We invented the hot solder leveler for making printed circuit boards. That soldering process is now used in most printed circuit board production. In just the last few years, a large number of other items have become public property. A new kind of drill but for the oil and gas industry with diamond cutters located on the bit by computer analysis, down-hole instrumentation for oil wells; a steam generator to facilitate down-hole production of oil; hardened semiconductor electronics—we are the national laboratory that makes radiation-hard silicon chips for weapons as well as for other uses; insulating glass that lengthens the life of pacemaker batteries; and many other similar kinds of things which are spinoffs from our weapon and energy programs.

I would like to spend a moment on one particular case because I think it illustrates some of the barriers to technology transfer. One of our people invented a pump which could be implanted in the human body and was externally controlled to deliver insulin to the area near the pancreas. Clinical studies were done at the University of New Mexico jointly with us under a National Institutes of Health grant, and it was discovered that insulin delivered in this way is a much better way to provide insulin to diabetics because it mimics the body's method of providing insulin and can be computer-controlled from the outside. It avoids side effects such as detached retinas and so forth.

When it became time to transfer that technology to the private sector for manufacture, we held a symposium. We had open bidding for the right to manufacture this device. The winning company was Shiley, a Pfizer subsidiary. The contract was entered into with the University of New Mexico and DOE, since we are a government laboratory and it was a joint activity. It took over 1 year to iron out the legal problems of liability, for example; if someone dies, who pays the bill? The legal questions raised by these joint arrangements, even in this instance, with a university involved, are very difficult when you get down to an actual case.

I'd like to mention one or two other points which I think are important. Sandia does, of course, manage certain programs from industry for the Department of Energy. An example of that is security fences around embassies or nuclear installations. The product, of course, comes from industry. The management comes from us. As a result, we must have no proprietary interest because then people would not trust us, nor would we be able to choose indiscriminately between suppliers.

It's therefore a little difficult, I think, to be carrying on at the same laboratory and at the same time several kinds of relationships with industry, some of which are contractual, where you must remain absolutely free of conflict; and others which could be joint. So there are some natural problems when a large laboratory, at least one like ours, gets into a variety of arrangements with industry.

One of the things I think is worth mentioning is that there are a number of myths floating around about what the technology in national laboratories really consists of. There are a few cases, and I have mentioned them, where technology is ready for production and where a patent may be involved. But most of the technology in our laboratories is not a finished product ready to go into industry. It is a piece of something; it consists of know-how about a particular process. It's a system which might provide a part of a product in the industrial world. Therefore, I think, to put too much emphasis on patents per se is to miss the bulk of the technology which is really there ready to be exploited. In my opinion, that technology is best exploited by a sort of grassroots approach in which the scientist or engineer who has knowledge missing in industry is able on a one-on-one basis to consult with or transfer the technology to people that need it.

The need, as has been mentioned several times, is a driving force. There must be a receptor on the industrial side. There must be someone there who can understand what's being said to them by the scientist in the laboratories. They must have a desire and a need to exploit the technology or they will not want to receive it.

Let me give you another example from Sandia which I think illustrates this point. At our Livermore Laboratory we operate a national facility called the National Combustion Research Facility. In that laboratory, lasers are used to diagnose the temperatures and chemical reactions that go on at the intersection point of two laser beams. That has permitted us for the first time to measure, on a noninterferring basis, what actually goes on inside an operating automobile engine. What are the combustion products? What are the temperatures inside the engine as it operates, as a function of both time in the cycle and space within the cylinder?

The results that came out of that were very interesting and exciting, and tended to change the views that people had about the way in which combustion products are formed. It was my observation that the Japanese automobile industry took immediate interest in this process, came to Livermore, and tried to understand what we were doing. American industrial firms are now very interested, but for a while they were reluctant because they feared one another more than they wanted the technology.

Now I think that means that the Nation needs to do something about the way in which technology transfer is to be made. Are we to make it indiscriminately available to anyone who asks, or should we preferentially transfer the technology to companies within the American sector? Because in many areas we are finding that some foreign competitors are more anxious, or at least as anxious, to obtain our technology as our own industry is.

Another point that may be missed is that there's a good deal of emphasis these days on helping State and local governments. Local governments are not interested in technology in general. They have no way of exploiting it. What they are interested in is staff time. They want someone to help them with a problem and in many cases we are willing to do that.

I am also of the opinion that focusing only on regional startups is a mistake. Our present national laboratories, like Sandia in a small State like New Mexico, will automatically have a large regional influence. We are the largest laboratory in the national laboratory system, and are one of the largest employers in the State of New Mexico, so of course, we're going to have a regional influence and we do have. However, when you talk about transferring technology, it's our experience that most times the technology is best transferred to an existing company with an existing need. A new, small startup company is a great thing and if you can make it work, fine; but as I said, most of our technology has been transferred to 300 existing companies. They are not exclusively small businesses and they are all over the United States.

I would like to say one or two things about what I consider to be barriers to innovation and technology transfer. I think that one of the principal barriers to new companies is the lack of supportive climate for the entrepreneur. A good deal of attention is being given to incubation centers, which are buildings where you have cheap rent, construction and shop support, computers, secretaries, and so forth, and that's very important. It's equally important, however, that the center be associated with a source of technology, and I think therefore that the most successful incubation centers are those associated either with universities or with a laboratory. What the Federal Government can do to sponsor these centers I don't know, but where they have come into existence, I think they really do have an important effect.

Finally, I'd like to mention what at least to us represents a kind of legal or conflict-of-interest barrier. As you know, the Economy Act prevents a national laboratory from competing with private industry, and I think that's right and proper. We cannot make a product instead of going to industry under contract if that product is readily available. Now is it competition if you form a joint venture? Is it competition if part of the revenues of the product come back to the national laboratory? Is there a conflict with the Economy Act?

I think these questions of conflict of interest need to be resolved. I think that the rights of the national laboratories to behave much like industrial laboratories need to be unambiguously stated in public law if we are not to inhibit people from taking risks.

Thank you again for the opportunity to talk to you.

Representative **Lungren**. Thank you very much.

Mr. Miller.

STATEMENT OF CHARLES F. MILLER, UNIVERSITY OF CALIFORNIA, LAWRENCE LIVERMORE NATIONAL LABORATORY

Mr. **Miller**. Thank you, Congressman Lungren. I'm very happy and pleased to be in Washington to talk about what has become one of my favorite topics. For over the past 12-plus years, I have been involved directly and indirectly with the technology transfer programs at the Lawrence Livermore National Laboratory and have spent almost 10 years in various positions with the Federal laboratory consortium. I had the pleasure of putting in a 2-year tour of duty at the National Science Foundation as program manager for the Federal laboratory program.

I want to base my views on technology transfer broadly over these years of experience. I confess that some of my remarks may also be colored by the fact that I am a proprietor of a small business which is presently marginally successful, a small business somewhat involved in technology transfer.

I thought it might be useful, as Mr. Brown did, to take an overview of the Federal laboratories in general and to look at some of the changes over the last 10 years, as seen from the trenches. I'm a little bit disappointed that so far I haven't found too much to disagree with with my colleagues, though I'm sure that if we start debating details we will find some areas of disagreement.

I thought it would be easy to readily pluck out some fine examples of what's been going on in the Federal Laboratory Consortium, but I found it very difficult to do. So many things have been going on. I have selected a few things to draw upon and say that these are good learning experiences.

Last week I found out that there are two other things that have been recently created. I received notification last week from the U.S. Conference of Mayors who are sponsoring a workshop-seminar in Washington in September entitled "Unlocking the Future—Federal Laboratories: The Key to Successful Economic Development," where they are attempting to link mayors and others in city and local government, along with the Federal laboratories and the universities, to address issues such as economic development.

Last Friday my friend at the National Bureau of Standards, Jim Wycoff, called to tell me about an affair that he had attended last week and about a program of which I was unaware. The NASA industrial application center in Pennsylvania had been contacted to look at issues involving economic development in northeastern Pennsylvania. They spent a year assessing the strengths and weaknesses in the multicounty area of northeastern Pennsylvania and last week held their first workshop. There were eight laboratories involved and something of the order of 100 representatives of industry trying to link technology sources with these local business and industrial communities, sponsored by a local economic development commission. He reported it to be a successful affair and it evidently is the first of several.

I mention this because there are a lot of things going on, I think it's good that there's a lot of things going on because even those of us who have made most of the mistakes feel we still have additional things to learn about how this whole process evolves.

I will list briefly some of the things that I think we have learned over the last 10 years—we being a sort of collective group within the Federal Laboratory Consortium.

One of the things we have learned is that we are living in a very nonheterogeneous world. It's so easy for us in the laboratories to speak of industry. Industry is very, very diverse, very, very complex. We have big business and we have small business. We have manufacturing industries and we have service industries and all sorts of mixtures.

The other side of the coin, it's very easy for industry whoever they are to say "Government laboratories" with a sweep of the hands. It's also a very, very heterogeneous group. Big laboratories, little laboratories, defense laboratories, agricultural laboratories, laboratories such as Sandia where they have a fine collection of engineers.

We also find that this whole process to move a technology or know-how from the laboratory to another party requires a heck of a lot of work both on the part of the technology provider and the technology receptor. It takes a lot of effort and it takes resources. To get this effort and these resources adequately allocated and spent, we need dedicated, committed people. Where do you get these dedicated, committed people? Well, where it seems to be working best is where both parties' mutual self-interests are being met.

If we have a new process such as that developed in the laboratory to machine precision optics, and we in the weapons business and others need precision machined optics, we would like to buy these from the outside world. But if industry doesn't have the capability to produce these for us, it's certainly in the interest of the laboratories to help industry adopt this technology so that they can produce those parts we need in our programs. Certainly it's in industry's benefit to pick up this technology so they can sell not only to the laboratories but they can perhaps find other uses for this technology. This occurred a few years back. It was a win-win game, a very successful transfer of technology.

There was formal funding allocated in the Department of the Air Force to do this, individual firms budgeted money and a trade association committed a good deal of money and effort in order to transfer precision machining technology. In the end, everybody won. This was an example of a case where you are almost assured there will be a successful transfer because of minimal risks and the probability that everybody is going to win.

Mr. Brown mentioned that laboratories and universities have somewhat of a mismatch in terms of language and culture. It's definitely true in terms of laboratories working with industry. These are two separate cultures and what do we do to get around that? We've got to work hard, and we've got to learn to talk to each other. I'm pleased to hear that you're holding hearings in my neck of the woods in Silicon Valley and will be speaking with industry folks. It would be nice if perhaps on this panel there were industry people. We need to be conversing at this level.

Another thought is that the proper role for the Government laboratory in economic development should be a support role. We are a technical resource, but we are not the only available technical resource. We do have certain resources available that can be drawn upon by others. The others include economic development commissions, and States working through universities to help establish incubator facilities, or to help establish industrial parks. Very rarely I think do we see a laboratory that would properly be in the lead role.

In my prepared statement I talk about one of the New Mexico laboratories, our sister laboratory in Los Alamos, which has indeed taken the lead in cooperation with the State and other laboratories in the State to develop an economic base in northern New Mexico. They are motivated by self-interest. They now have to go to southern California to get fabricated parts and why not have this in Santa Fe?

I don't think we will find a situation in many other places such as New Mexico with a fine laboratory, an excellent university system, supportive State government and industry willing to move firms to the State because it's a desirable place to live and work.

I think, rather, we will see sporadic things such as we find in Pennsylvania where the Government laboratories will serve as a resource or we will see, rather than a regional economic, we will see an industrial crosscutting type development such as in precision engineering where we dealt with companies across the country who were in a narrow industrial base.

I also agree with the previous speakers that the laboratory is not a little warehouse where one can run in and grab this technology and take it down to the supermarket for sale.

From personal experience, a good deal of the work that is completed in the laboratories is not ready for the marketplace. Oftentimes, it requires a considerable amount of engineering in order to make it producable and put out a reliable product that can be adequately serviced in the aftermarket by the manufacturing dealer. A good deal of work must be done beyond releasing the report drawings.

It was rather interesting when I was preparing to come back here, I reviewed a lot of my old notes and some of my past books and I went through hearings which were held by the House Subcommittee on Science and Technology in 1979 for several days looking at Federal laboratories and the technology transfer, and I was very pleased to have it brought home to me how much has been done in 5 years.

Now to those of us who don't have to be elected to their job every 2 years, 5 years is not a very long time, Congressman. I was quite surprised to see how much had been done, looking at the recommendations of the various witnesses and how much it was folded into Stevenson-Wydler law in section 11 particularly.

So looking at where we were 5 years ago and where we are today, I tried to address your questions as to has Stevenson-Wydler helped? Yes, overall, it's helped. In some laboratories who were active in technology transfer before Stevenson-Wydler, it allowed them to come out of the closet a bit and provided them a little more work because of reporting requirements. Other laboratories who had been inactive in technology transfer are active now in technology transfer.

Overall, on a national scale, the fact that we have section 11 of Stevenson-Wydler means that we do have more activity in the Federal laboratories in technology transfer.

Some of the laboratories are still having some troubles with Stevenson-Wydler. Often there are complaints on the part of the laboratories that there's not enough money available. We cannot do our job because we cannot get budgeted funds. This is especially true with smaller laboratories, those laboratories which are funded on what's called an industrial basis. It's not much of a problem in the large multiprogram laboratories because they can generate internal overhead funds.

There are those that advocate that we should have line item funding for technology transfer. My personal feeling is that I don't like line item funding for technology transfer because that's one of the first things that could be cut out of a budget when you get into markup appropriations in order to save money. Section 11 does require each agency to set aside one-half of 1 percent of their research budget to support technology transfer from laboratories. That should be sufficient. If it's not sufficient, if some of the laboratories aren't getting sufficient funding to do their job, then perhaps something is wrong with the application of the law.

The law also requires larger laboratories to devote at least one full-time person to these activities. There are reports that this isn't being done. It appears that there are some administrative difficulties in getting this provision properly applied.

We've also heard comments about lack of incentives and the presence of disincentives on the part of the laboratories to encourage technology transfer not only for the people involved directly in technology transfer but for the bench scientists and engineers. There are proposals to pay awards and a share of royalties to the individual laboratory inventors, but there are many nonmonetary rewards and nonmonetary incentives that laboratory management could offer. You get a lot of mileage out of an award in your personnel file.

We also have found difficulties in implementing agency's wishes in the field. It's one thing for the headquarter people to say "we have now a new broom and we're sweeping clean" and "we are going to do things differently," and "we're going to go on joint ventures with industry." But by the time agreements are negotiated and submitted for bureaucratic review and approval, one hits a brick wall. There are no incentives for a man in the field to be administratively innovative, to do something that isn't precisely spelled out in his orders. There are a lot of disincentives, sanctions and punishments, if he does new things and screws up; nothing if he does new things and it goes well. We find that things tend to get bucked upstairs to a higher and higher level because of new things.

Again, the law provides authority for this but there's agency management difficulty. We trust this will be worked out with time as we learn more about how to do these things.

Finally, I have been asked to make a statement about application assessments. The application assessments are spelled out in the Stevenson-Wydler Act such that each office of research and technology applications should prepare technology assessments on those technologies that are felt most suitable for transfer and commercialization.

On the one hand, I hear from industry that they don't want the Feds trying to decide what's good for them—"let me come into your shop and I know what will fulfill my needs." On the other hand, I hear from the people in the laboratories that, first of all, they are uncomfortable about trying to say that this is a good thing to go outside. They also are fearful of saying, "Gosh, when my performance appraiser is in here they just might count up all the application assessments I have prepared, so I'd better dump out a whole bunch of them."

The section 11 does have flexibility and I believe these flexibilities will allow each laboratory to determine the best application assessment, whether they put them out or not, and I believe the authority is there to do that.

Thank you very much.

[The prepared statement of Mr. Miller follows:]

PREPARED STATEMENT OF CHARLES F. MILLER

Mr. Chairman and Members of the Committee:

It is an honor and a pleasure to appear before you today to express my views on the role of Government Laboratories in regional economic development. Thank you for the opportunity. My views are based principally upon my observations and experiences as a member of the Federal Laboratory Consortium for Technology Transfer (FLC) and as Program Manager for the Federal Laboratory Program at the National Science Foundation for two years.

FLC BACKGROUND

The FLC was formed just over 10 years ago, and its members now represent over 200 federal laboratories from 11 agencies. The overall objective of the FLC is to assist member laboratories and centers and parent agencies with technology transfer in response to members' needs and requests. Contrary to a fairly prevalent misconception, the FLC does not transfer technology per se; rather, the individual laboratories effect the transfer, and often, the bench scientist or engineer does the work, not the FLC member. The FLC acts to create and test mechanisms and methodologies for technology transfer, to broker requests for assistance or information, to aggregate needs, and to represent the federal laboratory community to potential recipients of laboratory technology.

Through the years, the FLC has sponsored a variety of activities in an effort to facilitate the process of technology transfer to the private and public sector. Many of these activities were designed as experiments or learning activities--attempts to determine what works and what doesn't work. A first major lesson learned was that this "system" consisting of federal laboratories (as technology sources) and state and local governments, academia, the private sector, and others (as technology users) is exceedingly diverse.

The federal agencies with R&D laboratories vary greatly in their missions, and the laboratories vary too in missions and also in manpower, budget, and other resources. Also, as the Federal Laboratory Review Panel of the White House Science Council reported, ". . . the degree of interaction with universities and industry varies among other laboratories visited. . ." Some laboratories, especially the large, multi-program National Laboratories, have long established formal institutional or other programs in cooperation with universities and the private sector. Other laboratories find such interactions foreign and worrisome. Another fundamental finding is that many of the federal laboratories do not seem to be able to identify who "their" industry is, or should be. This seems to be true of laboratories with a predominantly basic science orientation and also of major basic research programs within the large, multi-program laboratories.

Industry, too, represents a very complex and multi-faceted target for federal technology transfer efforts. As with the laboratories, industrial firms vary in size and products (missions). At one extreme, the large, Fortune 500 companies may have substantial corporate interest in keeping abreast of new, federally-developed technologies, and it is not uncommon for a large firm to initiate a team visit to a laboratory for briefing on on-going research. At the other extreme, the small or newly-emerging business is typically not interested in applying part of its limited resources to what is perceived as the long, tedious, and expensive process of dealing with the government in any way.

FLC ACTIVITIES

With this background of the many FLC projects and demonstrations and with the desire of the laboratories' management to increase relations with industry, the FLC chartered an Industry-Federal Laboratory Interaction Working Group at its May, 1984 meeting. This interagency group is charged with determining what laboratory transfer processes or mechanisms work, or are expected to work, to achieve one or more of the following goals.

- Transfer of information to industry.
- Transfer of inventions to industry.
- Industry/laboratory collaboration.
- Use of laboratory facilities.

The Working Group's initial effort is to develop an evaluated database of what transfer mechanisms or processes have been used or are contemplated, which ones have been effective, and what has been the cost. Industrial inputs will be sought during the study phase.

The product of the Working Group will be a handbook which will characterize successful processes or mechanisms and provide guidelines to laboratories which wish to design and implement new initiatives. The timetable for this effort calls for the data analyses to be complete in spring, 1985 and for publication of the handbook by the end of summer, 1985. We anticipate that the data-gathering phase will provide some insights into barriers and other issues which may hamper or impede laboratory/industry interaction. To this end, we are very interested in the results of these hearings and are open to suggestions as to the conduct of the Working Group's study. We would also be very pleased to keep committee staff apprised of the findings of the study.

At this point, I would like to describe a few past activities of the FLC which were attempts to form tighter links between the member laboratories and potential technology users.

Technology Action Center was established in Santa Clara, California, in 1978 as a joint effort of the Santa Clara Chamber of Commerce, the FLC, and the Southwest Innovation Group. The Science Advisor to the City of Santa Clara was appointed as part-time director to the Technology Action Center (TAC) with offices in the Chamber of Commerce. The director served as a point of contact for Silicon Valley industries and had direct access to the federal laboratories. The project operated for a few years with mixed results. Although some specific excellent transfers occurred, TAC was unable to mount the sort of marketing effort necessary to develop and maintain a sustained high level of user demand.

Technology and Business Opportunities Conferences were held in Philadelphia (two conferences), Baltimore and Albuquerque. These conferences with associated exhibitions were designed to present to local and regional business and industry community a wide range of technology transfer and assistance programs to stimulate economic development. The conferences were endorsed by the state's congressional delegation and were co-sponsored by agencies; such as, the Small Business Administration, Federal Regional Councils, local and state governments, and regional economic development agencies. Each of the conferences was attended by dozens of laboratory representatives and hundreds of business and industry representatives. Positive results were reported from each conference, and it is believed that the Albuquerque "Showcase for Technology" served as the kick-off for New Mexico's Program for Economic Development. With the exception of the Albuquerque conference, post-conference interactions tended to dwindle to a few on-going or sporadic activities. Continuing, planned, and formal follow-on efforts seem to be required in order to build upon and enlarge contacts made at conferences of this sort.

Industry/Federal Laboratories workshops have been held in cooperation with a nonprofit corporation, Technology Transfer Conferences. At meetings in St. Louis (2), Baltimore, and Los Angeles, some 30 laboratory representatives met with over 100 industry people for detailed, two-day, one-on-one sessions dealing with selected, specific technologies suitable for transfer. Based upon the success to date of these workshops, Technology Transfer Conferences intends to continue the program.

Laboratory Interactions with Trade Associations seems to be a promising mechanism to transfer laboratory technologies which are more generic in nature. In one demonstration program, the Mining and Reclamation Council of America (MARC) developed a list of research needs of its members. When technologies were identified in the laboratories which were relevant to those needs, reports were submitted for review and distributed to MARC membership via magazines, newsletters, and special mailings. This experience showed that this is an excellent method of informing targeted industries of selected available technologies, and this method seems to be most effective if the material is presented in a short, concise form that is easily scanned.

A Technical Volunteer Service (TVS) is now in place in many laboratories and is planned for many more. The TVS concept was developed at the Naval Underwater System Center in the 1970's and draws upon active and retired laboratory employees to provide needed technical assistance to their communities and others. With funding support from the Department of Army (DARCOM), the Department of Navy, and the Administration on Aging, the TVS program was documented and replicated in a large number of laboratories. The TVS programs are reported to be very well received both within the user communities and in the laboratories. In recognition of these activities, two laboratories have received the President's Volunteer Action Award Citation. The TVS programs seem to be the best mechanism to meet the needs of state and local government for technical assistance. In addition, schools and other public agencies and small businesses are becoming active users of the services of the technically trained volunteer.

A NEW INITIATIVE

For a moment, I would like to depart from FLC activities to report on a new and unique program directed specifically towards regional economic development. The Los Alamos National Laboratory has begun major initiatives to promote technology-based economic development in Northern New Mexico, in recognition of the central role of small-business innovation in the nation's economy and the need and value of economic diversification and development in its neighboring areas. The Laboratory has established as a goal to "participate in development of an environment of high-technology and industry and individual entrepreneurship in Northern New Mexico." To meet this goal, the Laboratory

- Was a primary sponsor and organizer of a "Workshop in Small Business Incubators" in April, 1984 as a service to local communities and others from across the U.S. interested in developing a supportive environment for small business start-ups. One result of this workshop is a community effort in Los Alamos to develop an incubator facility and seed capital fund.

- Encouraged members of the technical staff to engage in technical consulting or personal business. Over 200 staff members now provide a direct transfer of laboratory-developed know-how into the private sector.

- Has cooperated with several state-level efforts to create a technical entrepreneurship network which represents the state's efforts in technology-based economic development and university programs to assist technical entrepreneurs.

- Hosts a monthly innovator's forum to expose the Laboratory staff to individuals experienced in technical entrepreneurship.

- Participates actively in the FLC, making its technology available nationwide through the FLC network.

- Cooperates with the Department of Energy, the University of California, and the individual inventors to facilitate the commercial availability of laboratory inventions. Resulting licenses or waivers of title have been sought almost exclusively by small businesses.

- Has encouraged appropriate assistance to Small Business Innovation Research (SBIR) program applicants and grantees, and has participated in programs to promote the SBIR program to potential applicants.

The new program at Los Alamos National Laboratory is one example of several which are now being planned or implemented at various laboratories. Many other examples exist of programs and projects specifically designed to not only transfer technologies to the private sector but to include U.S. industry as a partner in the federal R&D program. With these laboratory activities and the activites of the FLC, it is possible to draw some general conclusions as to the nature of successful technology transfer.

CONCLUSIONS

1. The chances for success of a technology transfer project are greatly increased when the self-interests of both parties are met. Both the laboratory program and the technology recipient must anticipate gains sufficient to offset the sometimes substantial investments required.

2. Successful transfers are also substantially dependent upon the talents and commitment on the part of the technology recipient as well as the technology provider. It has now become a cliche that "Institutions don't transfer technology, people do," and one cannot overstress the importance of person-to-person interactions.

3. One of the most common barriers to technology transfer from a government laboratory to the private sector seems to be ignorance: Laboratories lack knowledge of the needs and capabilities of industry, and industry can see little benefit in working with a government lab. This lack of knowledge can lead to distrust, adversarial posturing, or, at best, indifference. It is incumbent upon both parties to learn the culture of the other.

4. Big business is very different from small business. Liekwise, large government laboratories are different from small labs. Just as industry varies from sector to sector, so do the Federal agencies differ from one another. In designing technology transfer programs, one must give full attention to these differences.

5. With respect to regional economic development, government laboratories can best be utilized as technical resources. In general, others should take the lead in catalyzing economic development programs. Exceptions to this could occur when there are identified direct, specific benefits to the laboratory.

6. A popular notion seems to be that government laboratories are stocked with technologies ready to be plucked from the shelf and dropped into the marketplace. Almost always, a technical innovation which adequately meets the needs of the R&D programs requires a considerable investment in time and effort to produce a commerically attractive product.

7. Resources allocated to technology transfer activities (on the part of the laboratories as well as industry) must compete with and be balanced against other demands for resources. Most often, only those activities with the highest priority or the lowest risk are funded. There is imbedded in this some upper limit as to the extent and scope of technology transfer.

ISSUES

In the late 1970's, considerable congressional interest in federal technology transfer was evident. This interest resulted in Section 11 of PL96-480, the Stevenson-Wydler Technology Act, ("Utilization of Federal Technology"). A review of reports, papers, and hearings relating to technology transfer shows a good deal of change and progress on the federal level. For example, many of the recommendations presented at hearings before the House Subcommittee on Science, Research and Technology in June and July, 1979, have been implemented in some form. Some issues remain, however.

1. Many laboratory technology transfer practitioners feel hampered by a lack of funding and advocate line-item appropriations for technology transfer. Lack of funding can be especially troublesome to smaller laboratories which otherwise have difficulty generating in-house or overhead funds. In addition, lack of up-front appropriations seems to automatically subordinate technology transfer activities to those programs which do have appropriated funds.

   The down side of line-item funding is, of course, the vulnerability to the blue pencil. In an atmosphere of pressure to reduce federal spending, an item labeled "Technology Transfer" in an agency's budget can be a prime candidate for reduction or elimination. Section 11 called for an agency to direct part of its normal appropriated funds to technology transfer. Rather than line-item funding, perhaps this provision is not in itself sufficient or is being inadequately administered.

2. There are few incentives for laboratory personnel to devote much effort to technology transfer, and there are often disincentives. Proposals

have been made for cash awards for patents and for inventors sharing royalties from licensed inventions. But more attention can be paid to non-monetary awards as a way to encourage technology transfer. For example, the FLC recently established an "Award for Excellence in Technology Transfer." The purpose of the award is "To recognize individuals, not themselves FLC representatives, within federal laboratories who have done outstanding work in transferring technology and to encourage them and their management to continue to transfer technology to outside users." Among the criteria for the award is that "The individual or group has demonstrated uncommon creativity and initiative in the transfer of technology" and that "Benefits to private industry or state and local government are significant."

At ceremonies held in conjunction with its May, 1984 meeting the first FLC Awards for Excellence in Technology Transfer were presented to 25 individuals. The awards consisted of a commemorative plaque, a letter of commendation (suitable for placement in a personnel folder) and a press release. Judging from the enthusiastic response of the recipients, the awards were welcome recognition of outstanding performance in technology transfer. Similar laboratory or agency awards could be established within existing authorities and budgets.

3. Many agencies have made major efforts to encourage new arrangements with universities and the private sector. As one example, the Department of Energy has published a "User's Guide to DOE Facilities" (DOE/ER-0174) which lists "user facilities" and procedures for access to the facilities. But Headquarters' wishes are often not well received in the field. We find, for example, that attempts to enter into joint projects with the private sector, where industry funding may be used to pay for research at the laboratory, are frustrated by administrative impediments. Deviations from the established way of doing business results in long delays in obtaining requisite approvals and in considerable additional efforts by all parties. A cause for some of these problems seems to be a lack of incentives. The perception is that there are few rewards for administrative innovations, even when they are done well, but there are many penalties for failure. These barriers,

however, can be resolved by agency management, and once the new ways of doing business become part of the established way of doing business, administrative impediments will be minimal.

4. Section 11 of Stevenson-Wydler has increased federal technology transfer efforts and, nationally, has increased technology transfer. Stevenson-Wydler has encouraged many more laboratories to establish active technology transfer programs than prior to the law, it has increased awareness of the problems and limitations in technology transfer programs, and it has made "technology transfer" an established part of the Federal vocabulary. Because of the recognized diversities in laboratories and users, the authors of Section 11 allowed for flexibility in implementing the law. This flexibility has been shown to be of value and should be maintained.

   The most troublesome part of Section 11 seems to be that of dealing with "Application Assessments." Representatives from industry have stated that they are not interested in "some Fed" determining what would be of interest to their businesses. Rather, they say that the laboratories should "show me what you have; I'll decide what's of use to me." Properly prepared assessments, however, can be useful in an overall marketing sense. Assessments can serve a examples of the types of technologies available with the goal of inducing the potential user to learn more. If application assessments are treated in this light, if the inherent flexibilities of Section 11 are recognized, and most importantly, if the number of application assessments issued by a laboratory is not used as a performance criterion, then we should continue to prepare assessments at the discretion of each individual laboratory.

I am pleased for this opportunity to testify on the role of government laboratories in regional economic development. The government laboratories do have much to contribute to improving innovation and economic development in the U.S. But government laboratories do not stand alone in these efforts. We must continue to work towards a full partnership among government, the private sector, and universities. The FLC is dedicated to this end, and we welcome your advice and directions on ways to proceed.

Representative LUNGREN. Thank you very much, Mr. Miller. Now Mr. Malecki.

STATEMENT OF EDWARD J. MALECKI, ASSOCIATE PROFESSOR OF GEOGRAPHY, UNIVERSITY OF FLORIDA, GAINESVILLE

Mr. MALECKI. Thank you, Congressman. I appreciate the opportunity to be here to discuss the connection between Federal laboratories and Federal R&D and regional economic development.

We have heard a lot this morning about technology transfers, technologies on the shelf and off, Government labs, research activity, but virtually nothing about regional economic development.

I suppose because my view will be from the ivory tower rather than from the trenches, I expect to be a contrast to some of the other witnesses you have this morning.

What I would like to do first is summarize some of my prepared statement which gives an overview of what Government laboratory R&D looks like from a national or regional economic development picture.

When we look at Federal R&D we see that it's very concentrated in relatively few places. Obviously, there has been a lot of what we could call pork barreling in the location pattern in the labs over the last few decades, but generally most Federal R&D, whether within the Federal laboratory system or otherwise, is in three areas of the country—the Northeast, which is a swath from Virginia through Massachusetts; the west coast but most notably California; and a kind of isolated case in New Mexico with its rather large and prominent labs.

The reasons for these are complex and have been fairly well documented in various reports and hearings over the years. An interesting thing that needs to be pointed out, whether looking simply at intramural R&D or funding through industry and universities, is the rapidly increasing share of defense R&D. And when I looked up some figures in preparing for this hearing I noted that in the 5-year period from fiscal year 1979 to 1984 the Pentagon's share of total United States R&D was to have increased from 45 percent to 65 percent. So when we talk about Federal laboratory R&D, defense R&D—and that means that done at the weapons test centers, at CERL in Champaign, IL, but predominently really at the large missile and weapons related research laboratories—is getting the bulk of the money.

Most of those innovations or technologies involved will not be readily transferable perhaps during our lifetimes, at least in the shortrun, for regional, much less national economic development purposes.

The other pattern that's interesting to note is that of industrial firms performing R&D. These also seem to take place within two general regions of the country, noticeably avoiding New Mexico. The Northeastern part of the country and California are the locations of the firms which are most directly related to Federal R&D either from the laboratory technology transfer system or from defense and other R&D activities.

We can also compare Federal R&D, whether done at laboratories or not, with industrial R&D and what we find is that for the most part industrial firms tend to concentrate within the same regions of the country.

So I look at this, as a geographer and researcher, for not just what could happen from technology transfers of R&D, but what does happen. We see that there are some major concentrations of R&D in the South. We have Federal R&D laboratories in places like Pensacola, FL, Atlanta, New Orleans, Oak Ridge, TN, which have generally failed to attract, to spawn, or otherwise generate any significant level of industrial R&D. They tend to be oases, so to speak, of R&D that remains strictly Federal.

For the most part the growth of the Sun Belt, if you look at the entire Southeastern United States which has boomed, has been completely unrelated to the growth of R&D at places like Oak Ridge, the Air Force base near Pensacola or even the military work around Orlando.

Why do we find an imbalance between industrial and Federal R&D? In general, we find that industrial R&D tends to generate spinoffs. We also tend to find a large range of industrial sectors. On the other hand, Federal R&D tends to be much more concentrated. It's concentrated in two industrial sectors if we look at the industrial classifications: Aerospace and electrical and electronic equipment. These industries are those that are highly concentrated in the West and Northeast and to a large extent explain that simple locational pattern.

Second, within these sectors, Federal R&D goes overwhelmingly to very large firms. Some data from the National Science Foundation industrial R&D report indicates that over 82 percent of Federal R&D goes to firms with over 25,000 employees compared to just about 67 percent of industrial R&D by firms of that size. So Federal R&D, both direct and indirectly through these technology transfer methods, has tended to be much more concentrated on larger firms. We have fewer companies with perhaps a large number of sites but a distinct pattern of location involved in them.

We do have some similarities also in the location of industrial-Federal R&D, and again the Northeast and California stand out. I'd like to probably preempt a little bit of what's going to go on in the field hearings to look at what has taken place from my ivory tower view in these two regions that could occur somewhere else in the country.

What we have in these two areas is a long period, probably now approaching about 40 years or more, of R&D largely funded by the Federal Government in these two regions. They have very strong universities where state-of-the-art research continues to be done and involves both small and large firms that support the military R&D effort as well as the rest of the Federal R&D effort. Strong and superior universities are the unique strength in the two areas. Nowhere else in the country is there the number of ranking research institutions and the per capita level of R&D performed.

There also is—and this has been a subject of a number of other hearings and studies—more venture capital present in these two regions than elsewhere in the United States. Where there is venture capital, where there have been successful entrepreneurial activities in the past, venture capital continues to flow. I believe that even if we had a Federal laboratory in a city such as Champaign, IL, there isn't the venture capital present there, and there will be little or no regional economic development that can be attributed to a laboratory in Champaign. I'm not trying to pick on my friends in that part of the country, but there will be very little entrepreneurial activity that could be considered to be a direct relationship between the Government laboratory activity and regional economic development in that area.

Venture capital is a catalyst only, I must point out, where a pool of talented people are present to develop commercial spinoffs of technology, and the unique characteristic of both the Boston and San Francisco Bay areas is the combination of academic, corporate, and Federal personnel providing the initial spark for dynamic regional development. They have provided the history and experience of entrepreneurship and they continue to attract people, capital, and ideas.

I think it is in particular the agglomeration effect, an agglomeration of different types of R&D, that allows regional economic development to occur. In the growth of these two prominent regions, the role of Federal R&D has been most important in indirect rather than direct ways and, in that sense, does not really apply to the specific context of this hearing.

In some regions universities seem to be critical, but we can also find examples where they seem to play minor roles and the importance of universities seems to be a direct influence only in the two regions that we are talking about here.

Within a setting of what we could call free enterprise, generating spinoff opportunities and so on from technology transfer, what specific role can the Federal R&D play? I'd like to suggest three for this hearing and then I will conclude.

First, even if the nature of the R&D is classified, esoteric or otherwise not commercially exploitable immediately, Federal R&D attracts highly skilled people who bring with them a set of values that complements entrepreneurial activity. The importance of science and technology and education and of a job market that rewards learning are common to all clusters of scientists and engineers. When the Federal R&D adds to an existing agglomeration of existing R&D personnel, such as the Route 128 or the Silicon Valley area, it also enhances the pool of technical workers who can potentially be lured to other, usually industrial, opportunities. This raiding of employees by other employers is part of the renowned dynamism so widely publicized in the Silicon Valley case.

Second, firms account for most Federal R&D and much of that from spinoffs which are the topic of this particular hearing. These firms, whether they're doing R&D directly for the Defense Department or another agency, tend to do their R&D at a relatively small number of locations where they can attract personnel easily. This need to attract workers is why only large urban regions are primary R&D complexes in this country, the only places where, I would suggest, Federal R&D has any notable effect on regional economic development. These highly educated people—as Mr. Miller called them, dedicated, committed people—prefer to have the diversity of professional, cultural, and recreational opportunities. Alternative jobs with similar employers in the same area are increasingly important as two career families or two professional-career families find it difficult to move long distances frequently. A larger urban area, especially one with a large number of R&D jobs, also has a cultural/leisure economic base with shops, restaurants, and services that appeal to an educated and well-paid population. An infrastructure of air transportation, communication, and business services, needed by firms and their employees, are also enhanced in large cities.

Third, and possibly most important in the long run, is direct Federal support of R&D at universities, or perhaps the stimulation of university relationships in technology transfer of Federal R&D. As Roland W. Schmitt of General Electric wrote recently in Science magazine, Federal support of university research is a critical and unique part of Government science policy. It is at research universities that new ideas and techniques begin, and where they become part of the training of new generations of researchers. Not all universities are going to spawn spinoff firms and most will not. However, if an area is a source of university basic research, of firms where local graduates can find employment, and to which researchers from elsewhere can be attracted, the economic development of that area will be based, at least in part, on those R&D activities. Where there are many universities and firms doing R&D in close proximity, this agglomeration effect is most significant.

I believe we cannot overstate the importance of university-based R&D and by this I mean dispersed university-based R&D. My first reaction to Colonel Theuer's remark that there were nine universities around the country which were getting transfers from the CERL lab, was to guess that a significant fraction of them would be on either the west coast or east coast. I'd like to find out which those would be in just a moment.

For the most part, as I said, from a national-scale set of studies on Federal R&D, it seems that the smaller isolated labs and their universities may be the site of a small amount of innovation, some of which may contribute to regional growth, but the significant ones are going to take place in existing clusters of entrepreneurial activity.

While I am not an expert on technology transfer—and I'm glad that the other three gentlemen with me at the table are—I would like to emphasize a second observation that again might be at odds with the experience of these other individuals. And that is that the large firms, which do not have to wait until an innovation or new technology reaches the trade journals, are more likely to have a network of people who are in touch with people at the Federal laboratories. The R&D labs of these firms are likely to be in the same regions, generally the Northeast or the west coast, and it is there that the commercially applied technology would be refined and prepared for some commercial application.

The examples of Sandia's clean room and the circuit board assembly are two cases in point. We don't find very much circuit board assembly or chip manufacturing in New Mexico. In fact, we find it now increasingly in Taiwan and Korea or Singapore or Malaysia, inducing I would say the regional economic development of those regions or countries as opposed to those in the United States. It's that kind of view that is perhaps at odds with what those governors and mayors and representatives throughout this country would be concerned about, but it is perhaps one that points out the fact that regional economic development is something that needs to be thought of at the regional level, and it also is something that needs to be contrasted with the dispersal which can so easily take place away from these regions.

In sum, Federal laboratories tend to either reinforce other existing R&D capabilities or serve as an oasis of R&D within an area. The advantage of the long-standing R&D complexes are many, and America's major corporations operate with efficiency and flexibility in and among these areas. Innovative activities take place, of course, outside these regions in many cities and towns throughout the U.S. Federal laboratories, by being large and in few places, can be a resource to local firms in those few places. The prospects for innovation and technological progress in our country are bright, but not primarily through the limited range of activities conducted in Federal labs. Support of R&D in universities and in small firms has a greater chance of dispersing benefits to firms and people throughout America.

Thank you for the opportunity to be here this morning.

[The prepared statement of Mr. Malecki follows:]

PREPARED STATEMENT OF EDWARD J. MALECKI

I appreciate the opportunity to discuss the connection between federal R & D and regional development. It is, I believe, a topic that has received relatively little attention. I have done a series of studies on the location and effects of R & D -- public and private -- over the past several years. I will attempt to summarize the pertinent portions of those studies as they relate to the concerns of this Committee and this hearing.

The Geography of Federal R & D

First, we can examine the geographical patterns of federal R & D -- patterns that, for the most part, have been persistent for at least twenty years. The most evident pattern is that of concentration in three areas: (1) the Northeast (from Massachusetts to Virginia), (2) along the West Coast, especially in California, and (3) in New Mexico. There are several reasons for these concentrations. Strengths in R & D for military purposes developed during and after World War II in both New England and California, and corporations in these areas remain major contractors forty years later. The universities in California, Washington, and New England are established research institutions, and perform above-average per capita levels of federally-funded research. In addition, government R & D facilities, notably the large energy laboratories, are few and far between, but several of the largest are located in either New Mexico or California. Further, a large concentration of federal agency intramural R & D is agglomerated in and around the Washington area in the District of Columbia, Maryland, and Virginia. In all, 70% of all R & D at federal laboratories is done in just 10 states (including the District of Columbia).

In any assessment of federal R & D, it is important to note the dominance of the Defense Department. From 45% in Fy 1979, the Pentagon's share of total U.S. federal R & D grew to 56.6% in FY 1982, and to an estimated 65% in FY 1984 (using data from NSF's Federal Funds for Research and Development, vol. 32). This suggests that patterns of government R & D now are shifting fairly rapidly, away from states where energy, environmental, and other R & D are conducted, and toward the traditional and growing concentrations of defense R & D. The top ten states in FY 1982 received 79.2% of all defense RDT & E contracts, and the level of concentration has been increasing in recent years. California alone received 39% of all defense RDT & E contracts in 1982. Once again, New England, California, and Washington are the beneficiaries, along with the Mountain states (Arizona, New Mexico and Utah).

Although defense R & D and its patterns begin to overwhelm the overall federal R & D picture, it is useful to briefly examine the patterns of the other major R & D agencies. The second-largest, the Department of Energy, funds less than one-fourth the level of defense R & D, and most of this (58%) is done at the major national energy labortories. The four largest, and seven of the ten largest, federal laboratories are Energy Department facilities, mainly in Western states, according to a recent directory by the National Bureau of Standards. Biomedical research within the Department of Health and Human Services' National Institutes of Health accounts for 10.8% of the total federal R & D effort. This is done primarily at colleges and universities across the country, although a large portion is conducted at federal intramural facilities, such as the NIH complex in Bethesda. NASA, at 8.4% of the federal total, is the last of the four largest agencies that together account for over 85% of all federal R & D. It combines two geographical patterns, one similar to Defense for R & D contracted to aerospace firms, and the other similar to Energy in that 38% of its R & D is done at a small number of NASA facilities, most in the South.

The geographical pattern of federal R & D, then, has three components. The first, and by far the largest, is the concentration at the locations of large defense contractors. California is by far the principal state, followed by Massachusetts, Washington, Florida, Maryland, and New York. The second pattern is that of federal R & D facilities, especially Energy Department and Defense installations. A few of these are located in large, isolated laboratories in states where little other R & D is done, but many of these large facilities reinforce the location of R & D by large firms doing federal or private R & D. The third, and smallest, pattern is that related to the nation's universities. Health-related NIH research and scientific research of all kinds sponsored by the National Science Foundation is dispersed among many major research institutions, but is rather concentrated geographically in states with clusters of great universities, such as California, New York, Massachusetts, and Maryland. The top 100 or so universities perform most of the R & D from every funding source, and twenty states accounted for 81.7% of all federally-funded university R & D in FY 1982. In sum, the industrial firms performing defense-related R & D determine most of the locational pattern of federal R & D spending. The other two patterns -- of federal facilities and of university research -- broaden the geographical distribution somewhat but also reinforce and complement the clusters of industrial R & D.

If we compare the geographical distribution of federal R & D with that of industrial R & D in the U.S., some major contrasts stand out. The most prominent difference between the two sectors is the concentration of industrial R & D in the Manufacturing Belt, from Massachusetts to Wisconsin, and the relative absence of it in the South. The larger concentrations of federal R & D in the South, such as Pensacola, Orlando, New Orleans, Oak Ridge, and the Research Triangle of North Carolina, have failed to attract, spawn, or otherwise generate a significant level of industrial R & D. Huntsville and Houston are perhaps the only places outside the Northeast or the West Coast to do so.

Why does this imbalance between industrial and federal R & D exist? The first reason is the concentration of federal R & D -- and especially defense R & D -- in only a few industrial sectors. Over three fourths of all federal R & D goes to firms in only two industrial categories: aerospace and electrical and electronic equipment. These industries are highly concentrated in the West and Northeast. Second, within these sectors, federal R & D goes overwhelmingly to large firms: 82.6% to those with 25,000 or more employees, compared to 67.6% of industrial R & D by firms of that size. Therefore, relatively few firms account for the entire geographical pattern of federal R & D, whereas industrial R & D is much more dispersed both across many industries and across the country. Having said that, the extremely low level of industrial R & D in the Southeast must be emphasized. In that region, a few large federal R & D facilities generally have failed to generate or attract industrial R & D.

Some similarities in the location of industrial and federal R & D also are striking. Again, the Northeast and California stand out. What is it about those regions, and not the rest of the country, that allows industrial and government R & D to coexist and even to mutally support each other? To answer this question, one must begin to look at the dynamics of R & D and the generation of economic activity within an area.

The obvious examples to cite are Silicon Valley and Route 128, which are America's beacons of entrepreneurship for other areas of this country as well as for the rest of the world. Federal -- that is, defense -- R & D played an important role in the formative development of both regions during the 1940's and 1950's (Dorfman, 1983). However, the R & D capability in both regions rests on the combined strengths of very strong universities, where state-of-the-art research continues to be done, and of a diverse base of small as well as large firms that support the military R & D effort. Strong, indeed superior, universities are the unique strength of the two areas. Nowhere else in the country is there the number of ranking research institutions and the per capita level of R & D performed (Malecki, 1980, p. 12).

In addition to federal R & D and universities, an element that has been common in Northern California and Massachusetts is ventrue capital, which allows innovative entrepreneurs to transfer their ideas itno a commercial reality. Venture capital has traditionally concentrated in these areas and apparently is entirely absent from some other parts of the country, as various studies and hearings have indicated. Venture capital alone, however, is a catalyst only where a pool of talented people are present to develop commercial spin-offs of technology. At the foundation of all technology transfer and, indeed, regional development, is people who are able and willing to adapt technology and ideas to other applications. Of all the regions of the country, the Boston areas and the San Francisco Bay area have the combination of academic, corporate, and federal personnel who provide the initial spark for dynamic regional development. Finally, there is also the role of history and experience. In those regions (and few others), successful technology-based ventures have attracted people, capital, and ideas on a scale not matched elsewhere, and they continue to attract them.

Regional Impacts of Federal R & D

What effect does federal R & D have on the process of regional development? In a study I completed a few years ago, three types of effects were investigated. The first, local income and multiplier effects in local areas, was statistically insignificant. True, a portion of the job market in major federal R & D locations will consist of professional jobs, but this effect is swamped by the similar impacts at larger industrial R & D clusters around the country. Federal R & D helps to create oases of higher-paying professional labor markets in a few areas that would not have them otherwise.

A second effect is the possible redistribution of R & D spending via subcontracting. In two examinations of this, using Defense and NASA data, it was found that subcontracting primarily reinforces existing concentrations of R & D and little widespread dispersal takes place.

The third type of impact is the most complex and difficult to measure, but at the same time probably is the most important. This I have called agglomeration of R & D. The location in the same place of several different R & D performers -- federal, industrial, and university -- gives to an area the breadth of capabilities and opportunities that can evolve into self-generating complexes of R & D and its outputs. These agglomerations, however, are few. In earlier work, for example, I identified 11 metropolitan areas in which both federally-funded and industrially-funded R & D are found on an above-average per capita basis: the four major American R & D complexes (Boston, Los Angeles, San Francisco, and Washington), three industrial cities where large federal facilities are found (Dayton, Houston, and Pittsburgh), two major university towns in the Midwest (Lafayette, Indiana, and Madison, Wisconsin), and two Sunbelt locations of federal defense-space facilities (Huntsville and Santa Barbara).

The agglomeration effect of R & D has the greatest potential for altering a regional economy, but only if a sufficient number of R & D activities are present to create a critical mass of people and activity. In such an environment, R & D and its output of ideas, new products, and new markets provide opportunities for entrepreneurs to form new firms (perhaps even in new industries) to take advantage of those opportunities. This spin-off from established companies represents the dynamic self-generating economic activity that is uniquely related to R & D. For several reasons related to the presence of such opportunities, high-technology industries are most likely to grow through spin-off.

The agglomeration of several different kinds of R & D activity is a hallmark of both the Route 128 and Silicon Valley regions. Even in the growth of those regions, the role of federal R & D has been most important in indirect rather than direct ways. Spin-offs of new firms are most likely to occur from other, established companies, and were least likely to be started by individuals working at federal laboratories (Cooper, 1971). Even universities vary in their "spin-off potential." Sometimes universities seem to be critical, and other times they play only minor roles. However, new business opportunities are more likely to develop out of large university research programs that are identifying new opportunities than can be exploited commercially. Small-scale programs at smaller schools are less likely to cover a range of basic and applied research topics. Most important is the corporate and entrepreneurial activity in an area. New firms serve as examples to other would-be entrepreneurs, and their success can attract the venture capital that is essential to the recurring ability of firms to get start-up capital. Although a region can develop via R & D without all of these ingredients, it remains true that our two shining examples include all of them: a big-city environment, superior research universities, federal R & D facilities, defense and other federal R & D contractors, and plentiful venture capital.

Within a setting of free enterprise generating spin-offs and opportunities, what specific role can federal R & D play? I would suggest three in particular. First, even if the nature of the R & D is classified, esoteric, or otherwise not commercially exploitable, federal R & D at a place attracts highly skilled people who bring with them a set of values that complements entrepreneurial activity. The importance of science and technology, of education, and of a job market that rewards learning are common to all clusters of scientists and engineers. When federal R & D adds to an existing agglomeration of R & D personnel, it also enhances the pool of technical workers who can be potentially lured to other, usually industrial, opportunities. This "raiding" of employees by other employers is part of the renowned dynamism found in the Silicon Valley region. The importance of a supply of technical people, both already employed and those being trained at local universities, is usually at the top of the list of location attractions of high-tech firms.

Second, firms account for most federal R & D, and most of it is from defense projects of various kinds. These firms continue to concentrate this R & D in metropolitan areas where they can attract the large numbers of scientists and engineers which they need. Even though substantial defense R & D is done at remote facilities, the major defense contractors tend to do their R & D at a relatively small number of locations where they will be easily able to attract personnel. This need to attract workers is why only large urban regions are prominent R & D complexes in this country and in most other countries. Highly educated people prefer to have a diversity of professional and cultural/recreational opportunities. Alternative jobs at similar employers in the same local area is, in fact, increasingly important as two-career families find it difficult to move long distances frequently. A large urban area, especially one with a large number of R & D jobs, will also have a cultural/leisure economic base with shops, restaurants, and services that appeal to an educated and well-paid population. An infrastructure of air transportation, communication, and business services, needed by firms and their employees, are also enhanced in large cities.

Third, and possibly most important in the long run, is federal support of R & D at universities. As Roland W. Schmitt of General Electric wrote recently in Science magazine, federal support of university research is a critical and unique part of government science policy. It is at research universities that new ideas and techniques begin, and where they become part of the training of new generations of researchers. Not all universities are going to spawn spin-off firms, and most will not. However, if an area is a source of university basic research, of firms where local graduates can find employment, and to which researchers from elsewhere can be attracted, the economic development of that area will be based, at least in part, on those R & D activities. Where there are many universities and firms doing R & D in close proximity, the agglomeration effect is most significant.

The importance of university-based R & D cannot be overstated. Dr. Schmitt's remarks focus on the long-run benefits of university research to the development of American science and technology. Few countries have a university system as open as ours to students of all types. The research and training of personnel represent the essential and general relationship between universities and industry. But it is also true that the location of concentrations of university R & D attracts industrial R & D. In some research that I have completed recently, federally-funded university R & D was highly significant as an influence on the location of industrial R & D, whereas direct federal intramural or laboratory R & D were not. The broad geographical patterns described earlier support this. States and urban areas with several top-notch universities are also the areas of concentration of R & D in industry, whether from industrial or federal funds.

Technology Transfer, Spin-offs, and Regional Development

While I am not an expert on the issue of technology transfer, as are the other witnesses at this hearing, I would offer a few comments regarding its role in regional development. Clearly, technology transfer can take place anytime or anywhere, as a firm or an individual takes a technology and uses in a commercially innovative way. But can federal R & D, as it presently is constituted, serve as a significant source for technology transfer that can lead to prolonged regional development?

There are two modes of technology transfer, each quite different from the other. One is based on large firms attempting to apply federally-sponsored R & D to commerical application. This mode of transfer is strewn with failures, as an Arthur D. Little study demonstrated several years ago. Even where there are prominent examples, most occur after the large firm takes the technology back to its own labs. From a regional development perspective, this moves the benefit of the transfer to another region. Only in a large, multi-faceted R & D environment is the transfer likely to result in the creation of jobs as the technology is further developed. All of our country's innovative firms have well-honed networks to gather information on technological opportunities from federal labs and elsewhere, but these are most often refined at one of the firms' own principal R & D locations.

The second mode of technology transfer is the more exciting, but less likely one in the current policy environment. It begins when a small firm or, rather, several small firms, are able to work on a succession of innovative technologies that can be commercialized. The early work on microelectronics during the 1950's and 1960's exemplifies this pattern, when small firms were as likely as (or more likely than) large firms to be the innovators. Necessarily, these dynamic environments were few, and the Boston and San Francisco Bay areas were the most prominent. However, I believe that other areas could, under the right conditions, be seedbeds of new technological activity, whether directly from federal R & D or indirectly from university research. Usually, it is easier for a small firm to develop and thrive in a large, technologically based urban area than in a small city, because of access to expertise, capital and personnel, and these advantages militate against widespread R & D-related development throughout the country.

Could federal policy be used more effectively to promote regional development? Even a large-scale program would probably not have that outcome. To focus on a few federal facilities or a few technologies would be less effective than to allow the researchers and their entrepreneurial counterparts to choose and develop those ideas that appeal to them. Federal support of that research and of its embryonic products would most closely recreate the aura of the 1950's and 1960's that are cited in this regard. Under any circumstances, the regions that have the potential to develop are those with the job markets, air service, and university research that have proven supportive of innovation-based economic growth. In addition, not many places can be seedbeds of a new technology; the strongest will rise to the top just as they do in corporate competition.

Most studies of technology transfer from federal labs and projects have emphasized the need for market orientation, both of the technology and of the means by which it can ultimately be commercialized. The government's relatively poor record of participation in directed technology transfer seems to be related to the lack of an explicit responsiveness to the market. However, the general problems of technology transfer, its failures and its successes, ignore the specific context of regional development.

Federally-sponsored technology whether in federal laboratories or in contractor laboratories, is monitored and participated in primarily by large firms. Only large firms have the necessary technical staff to acquire, analyze, and adapt technology from outside sources, such as federal laboratories. In addition, large firms can afford to have a long-term outlook that allows them to keep informed about technologies with no immediate application. Middlemen, such as university researchers, can, at times, help small firms to become aware of, or utilize, such information, especially the small, incremental technological improvements that can be especially important to a small firm.

The different nature of large and small firms in technology transfer is critical in the context of regional development. Large firms can monitor activities at the many federal laboratories conducting R & D of interest to them. Small firms are nearly always local, operating in the vicinity of a single laboratory on which it relies for information. The small firms will tend to utilize the technology locally, as recent examples around Oak Ridge and Los Alamos National Laboratories suggest. But large firms absorb such information into their existing R & D networks, which tend to be concentrated in the traditional regions -- the Northeast, California, and a few other places. At the same time, the regions where small firms are best suited to technology transfer activities are the same R & D complexes, where infrastructure, universities, and support facilities are readily available.

The issues of information transfer and of absorption and adaptation of technical knowledge are complex, and that is why large corporations are best equipped to deal with them. In addition, large firms can afford to wait and watch while a small firm makes early use of new technology, and then acquire either the technology or the entire innovative firm. In either event, the most likely geographical scenario is that much innovative activity will be transferred to a corporate R & D center.

In sum, federal laboratories tend to either reinforce other existing R & D capabilities in some regions or serve as oases of R & D within an area. The advantage of the long-standing R & D complexes are many, and America's major corporations operate with efficiency and flexibility in and among these areas. Innovative activities take place, of course, outside these regions, in many cities and towns throughout the U.S. Federal laboratories, by being large and in few places, can be a resource to local firms only in those few places. The prospects for innovation and technological progress in our country are bright, but not primarily through the limited range of activities conducted in federal labs. Support of R & D in universities and in small firms has a greater chance of dispersing benefits to firms and people throughout America.

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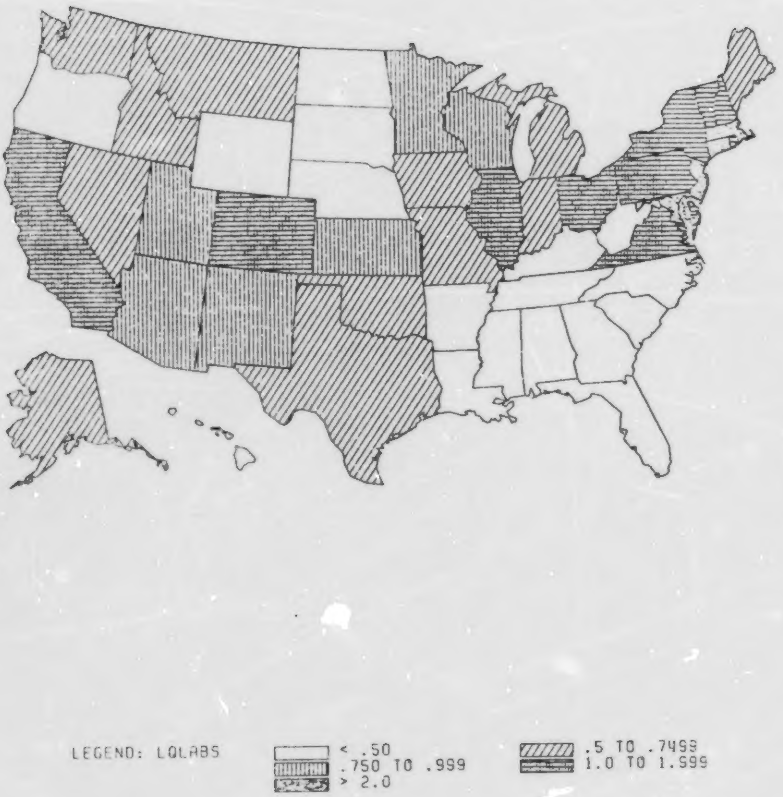
LEGEND: LQLABS
< .50
.750 TO .999
> 2.0
.5 TO .7499
1.0 TO 1.999

FIGURE III-2.
LOCATION QUOTIENTS FOR NUMBER OF INDUSTRIAL R&D LABS, 1982

SOURCE: See Figure III-1.

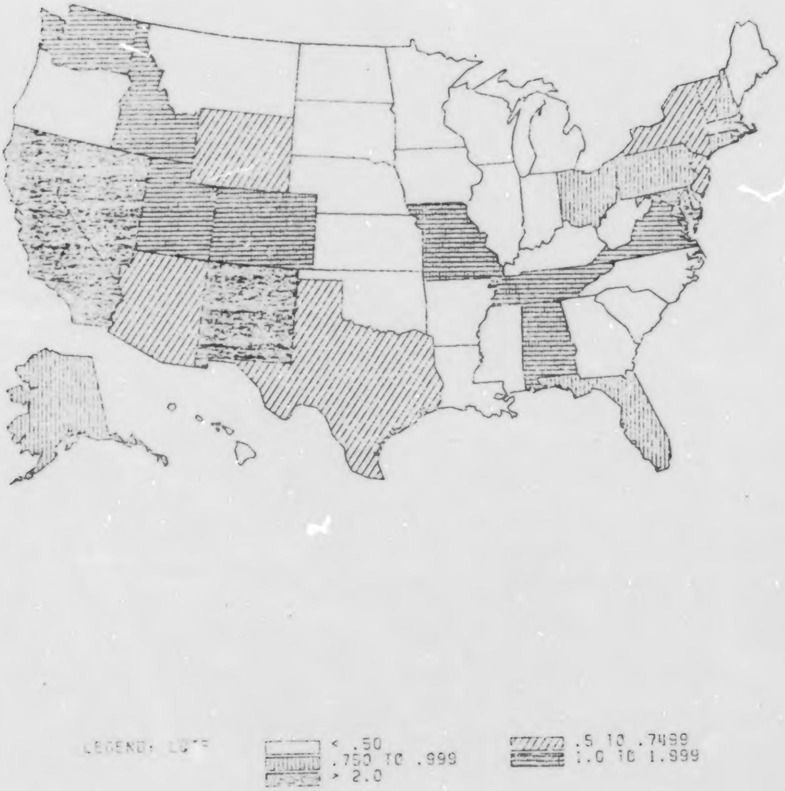
LEGEND: LQTF
< .50
.750 TO .999
> 2.0
.5 TO .7499
1.0 TO 1.999

FIGURE III-3.

LOCATION QUOTIENTS FOR TOTAL FEDERAL R&D, Fiscal Year 1979

SOURCE: Calculated from data in NSF 80-318.

Representative LUNGREN. Thank you very much.

Colonel Theuer, maybe you could respond to the comment made about the universities and where they are located, if they are on the east or west coast.

Colonel THEUER. First of all, we have relationships with universities in general in three different ways—with students, with faculty, and with universities on a contract basis. Those with which we have formal relationships are Illinois, Purdue, VMI, the University of Mississippi, University of Texas at El Paso, Georgia Tech, Connecticut, Pittsburgh, and Michigan.

We also have relationships in other areas with Carnegie Mellon, with Penn State, with whom we will soon sign a contract, and Mr. Shaffer within the next week or so will be meeting with the University of Texas at Austin. We also have people in contact with MIT. So that would be a total of 13.

Representative LUNGREN. I was hoping you were going to mention California.

Colonel THEUER. We attract a number of students and faculty from Stanford.

Representative LUNGREN. Let me ask a question that doesn't relate to the present point but we will get to some of those points as well.

One of the points raised by most of you is the need for incentives if we are going to make technology transfer work, and there seems to be a suggestion that we need to focus more on incentives, both from the standpoint of the private sector and from the standpoint of the Government lab or agency.

I wonder if the first three of you might comment on what specific incentives you believe would be most effective. I believe all three of you mentioned that there has to be an interest on the part of the private sector party to the joint venture, some incentive interest there. I wonder if you would address that and also address what the incentive would be to the Government agency and not just the Government agency but the person working for the Government agency. Is there something that is needed more than just the suggestion that once we have this technology we obviously have to have a supplier who's going to manufacture something that takes that technology and actually puts it into production form. We need to go further than that and have some incentive of a financial nature or some other nature to the individual scientist or engineer that's working for the agency.

Second, are you suggesting that you need incentives so that the money that's returned for licensing or similar type matter, at least a part of it, would go to the agency involved as opposed to it going to the U.S. Treasury?

Colonel THEUER. These views are mine based on experience at USA-CERL. Talking first about the laboratory. The incentive at the laboratory level is to, as I mentioned in my statement, to get the product out and make it available to the Army user. The requirement comes to us from the defense user primarily to solve a general or specific problem. The incentive from the laboratory's point of view is to take the requirement to the point where the solution is workable or pragmatic from the user's view as opposed to only publishing a report. My incentive as the lab director is to serve and meet the needs of the user. That's the first incentive.

On the part of the Government agency, I would interpret Government agency here to be the "State." I don't think the Federal Government can do much to assist in the process of getting the technology out there in a practical, usable, profitmaking sense, I think the focus and the impetus has to come from the State. States, by definition, work to attract business to their respective jurisdictions. The process is best portrayed as a triangle. The triangle involves the lab on the one part is a resource; the elected Senators and Congressmen and the State legislators on the other part; and the industry that might have an interest. And the incentive must be with the State to provide the focal point to draw the three parts together. We can't do it alone at a laboratory.

On the industry part, especially from the standpoint of a small business, but even from the standpoint of a large business, how does any size of industry come to learn of available federally developed technology? Let's say you're a manufacturer, you have 25 people in your firm in Long Beach. I ask you the question, "How do you learn for example that the Naval Research Lab is developing a technology that you could use in your company? How do you know that the technology even exists?" The incentive in this instance is for industry to somehow link up with available applicable technology.

Representative LUNGREN. Mr. Dacey.

Mr. DACEY. Well, my view, based on 30 years at Bell Laboratories and a total of about 6 now at Sandia, is that incentives are of such a variety of kinds that you can't focus on any one. Monetary incentives I think are least important. There may be an occasional patent that makes a millionaire out of someone, but most patents don't give that much money. And as far as monetary rewards are concerned, scientists and engineers are reasonably well paid.

I think that the major incentive comes from the feeling of accomplishment, from the feeling of contribution, from the feeling that you're doing something that is expected of you both by your company, your country, and your peers. And then I think it's a question of management style and somehow getting across to the laboratories that it is a good thing to transfer technology, and they in turn making their people feel that it's a good thing to transfer technology.

At Bell Laboratories, for example, a young engineer signs a patent agreement and for $1 all the patents that he ever makes will go to AT&T. That doesn't stop him from patenting. The record at Bell Labs is more than a patent a day. The patent portfolio has more than 10,000 important patents in force. The reason is because a person gets a kick out of making a contribution and of seeing his work actually result in something useful to people. I think that that kind of incentive may be missing in some of the national laboratories. The feeling you get when you can see that what you did actually results in something useful to somebody is a cultural matter, and not a money matter, in my opinion.

That's not to say that patents and even patent royalties and rewards of various kinds aren't important. They are important, because they give a signal that this is something that is a good thing to do. It's not the money itself; it's the fact that the company cared, that the country cared, and that some recognition was given of this kind of activity rather than just the purely scientific activity.

Representative **Lungren**. Are there, however, additional incentives in your view of whatever nature that we need to look at with respect to accelerating the process?

Mr. **Dacey**. Yes, I do. I think that if you look at what's in it from industry's standpoint, industry will be interested in exploiting a technology or an invention if they feel that there will be a contribution to the bottom line, and an important part of that is a proprietary right which prevents others from competing unfairly after one company has made a major investment.

In my opinion, the Government could couple some sort of proprietary rights to technology with the willingness to invest, so that companies which invest will get more rights to these technologies coming from the Government than those which do not. If you make it all free for everybody, it tends to be worth exactly that; exactly what people have put into it. From the standpoint of private industry, I think the incentive is the ability to make a profit. That, in turn, depends on proprietary access to the technology.

I think a lot could be done if there were some incentive to the national laboratories for having their technologies transferred, some sort of recognition, some way of reassuring them that this kind of activity is given importance and appreciation by the country, and perhaps also a greater degree of freedom for money generated by such technical activity to come back to these laboratories and inspire even more work along the same lines.

For example, we at Sandia have a program which we call "Distinguished Members of Technical Staff." People who are well along in their careers and have made significant contributions, including those to technology transfer, get a new title, "Distinguished Member of Technical Staff," a $1,000 grant, and a plaque which they can put on the wall.

Those kinds of incentives, while not enormously valuable from a dollar standpoint, make it very clear to people around those who get these awards that they have done the kind of thing which management thinks is good.

So I think there's a whole variety of different things we could think of to provide incentives, but we have to mean them. We have to mean that we really want people in the laboratories to do those things because, you see, they are to some extent in competition with other things that are expected of people in the lab. After all, a lab has a mission. They're supposed to do certain things. They are supposed to meet a certain date on a piece of hardware. That's their principal job. Those other things are spinoffs.

Representative **Lungren**. Mr. Miller.

Mr. **Miller**. It was very interesting to me to hear the commander of CERL and the president of Sandia reflect on their personal views of what incentives are because I think you need top management commitment to send these signals down through the ranks that, yes, indeed, this is important to our organization and, more importantly, this is a part of your job and if you do it well you will be rewarded for doing this well as you do everything else.

I wish I had more current knowledge about what is going on with respect to the Oak Ridge National Laboratory. You may be aware that Martin Marietta recently assumed responsibility for operating the Oak Ridge Laboratory for the Department of Energy. I heard several weeks ago that contract negotiations were ongoing such that rights to licenses and patents will be assigned to Martin Marietta. They, in turn, would attempt to license these out to local businesses. Part of the royalties would accrue to the inventors and part would accrue to Martin Marietta as an incentive to transfer technology. These royalties to Martin Marietta would be used only in support of like activities. They wouldn't go back to the corporate treasury.

Mr. DACEY. Well, yes, I think that's right, with one slight correction. That contract, as far as I know, has not yet been signed. At least it wasn't last week, because it does contain some of these controversial features.

One such feature was the notion that Martin Marietta's fee would be increased if there was a spinoff of technology into the local regional area, and I can imagine that that's controversial to people outside that area.

At any rate, there are a number of features in that contract being discussed which deal with the question of technology transfer. It will be very interesting to see what form it takes when the Department of Energy finally gets around to signing it.

Representative LUNGREN. I wonder if the first three of you might respond a little bit to Professor Malecki's point. Although we didn't confine this hearing to the question of regional development, that is a part of it, and Professor Malecki makes a point that, in fact, if you get outside of California and the Northeast area, laboratories do not do much, as I understand his testimony.

Perhaps Mr. Dacey could respond to that because you seem to be in the unique position of not being on either coast and in an area that would not really come to mind to most people. Unfortunately, they don't recognize the eminence of your institution or its location.

Mr. DACEY. I would certainly agree with what Professor Malecki says about the importance of synergism between laboratories, universities, and industrial companies. An existing infrastructure—a sort of ferment of activity and technology—clearly provides a seedbed that any one of those elements alone cannot provide as well. Therefore, I completely agree with the fact that if you have a good university system, if you have a good laboratory system, and if you have an existing infrastructure of industry, you're more likely to have a growth of innovation than if one or more of those ingredients are missing.

With respect to New Mexico, I think that we are on the verge of seeing it happen there and in the Southwest generally. The university system in Arizona is being substantially increased right now. We now have in Albuquerque a large new Intel plant where they will make their newest 6-inch wafer design on the most leading edge of the technology. Sperry has a plant there. GE has a plant there. These are relatively new. So we are beginning to get an infrastructure of industry coming, primarily because of the climate and to some extent because of labor conditions and living conditions, but to some extent because of the existing labs there as well.

The university system is in the process of trying to improve itself. I think it's fair to say that at the moment, if an industrial company were choosing between going, let's say, to the Austin area or to the Albuquerque area, they would, and in a couple of instances recently, have chosen to go to Austin because that university is more eminent and more wealthy than the University of New Mexico.

The State has recognized that and there is right now, a funded attempt called the Rio Grande Research Corridor to establish within the New Mexico University system some centers of technical excellence with the explicit purpose of trying to draw companies and high tech industries into the Rio Grande corridor.

It's a kind of historical development. I would hope that 20 years from now when Mr. Malecki gives his testimony at another congressional hearing which is still trying to accomplish technology transfer, he will be able to cite three regions.

Representative LUNGREN. Let me ask you this question. Do you have any doubt in your mind that at least part of the evidence for the development of that infrastructure or the further development of that infrastructure and improvement of the university system is from the existence of your institution?

Mr. DACEY I think it would be very difficult to do without it because it's all a kind of bootstrap operation which does require the presence of a number of educated people who care about education, who care about learning, as Professor Malecki said. The existence of the national laboratories, with several thousand Ph.D.'s and with their concern about educating their own children, with the natural spinoff of the cultural and intellectual things which their interests provide, I think would be essential to a region. Some start has got to be made and I think the national labs in New Mexico are an asset which will enhance this growth.

It requires more than that, however. It requires dedication on the part of the State government, on the part of the university people. In New Mexico, for example, if you look back in history, Los Alamos National Laboratory was established there to design nuclear weapons because it was an isolated place where security could be maintained. It also happened to be a place which Oppenheimer liked. So they went there. That laboratory grew and it was an oasis as far as any other technical activity was concerned.

The university system then had essentially a rural kind of orientation. New Mexico historically has had extractive industries, plus farming and ranching, and therefore the State population didn't have much appreciation for development. And that's important, too. People have to want industries to come to their State or there won't be a hospitable climate and industries won't come. That has been changing. It takes time to build on the national laboratories, but the companies are coming now, and ultimately the university will get better, and it will happen, but it takes a long time. If you had looked at Route 128 or Silicon Valley 40 years ago, you wouldn't have seen very much either.

Representative LUNGREN. I wonder if you might talk about the problem that we have, at least it was alluded to I believe by Mr.

Dacey and perhaps Mr. Miller, of foreign companies from foreign countries apparently either are more interested or more persistent in their pursuit of technology transfer from U.S. Government agencies. Do we have notable examples of an instance where that, in fact, has occurred? I just heard this said many times, that they do a far better job and that they get this information, or at least seem to pursue this information at the beginning more aggressively than do American firms. Has that actually been the case?

Mr. **Dacey**. I can give you two examples of where that is, in fact, the case. As we said earlier, the industry which is receiving the technology has to be somehow ready and anxious to receive it, in which case the national laboratories will be more anxious to give it. It takes two to tango, so to speak.

The Japanese are organized as technology receptors. There's no question about that. They have, through MITI and other infrastructure organizations, organized a kind of Japan, Incorporated, approach for competing in the world. They recognize, I think, more than most, that getting high technology is important to Japan if they are going to continue to thrive and, therefore, I believe they are ready to receive it.

I think some of our own industries, including the more smokestack industries, do not have a tradition of research, a tradition of receptivity to new technology. The steel industry is a good case in point. The Department of Energy right now is trying to arrange an experiment in which the national laboratories having materials science of interest to the steel industry will, in some sort of consortium arrangement, provide a formal means of spinning off technology to the steel industry. Well, while all of this is going on, while we are trying somehow to form a scientific attitude in our steel industry, some of our people from Livermore went to Japan on a scientific exchange visit and visited Nippon Steel and found that they are now using the laser technology that we talked about a moment ago to look at the temperatures in their steel mills and to control the formation of slag. They think that's very important and they are not able to get it quite working right so they want to come to Livermore, which is the center of this technology, and get us to help them make their system work. I doubt that you would find a laboratory in the American steel industry that even knew what "Roman Spectroscopy" was all about. So it takes a kind of anxiety to acquire technology.

Now, as a counterexample to that, in our work on hardened microelectronics, there's a good deal of interest on the part of American industry to learn this technology. In fact the Harris Semiconductor Co. put out a brochure recently in which they say they now have available this and that chip based on Sandia's technology. But that's because they do have that receptive attitude.

So I think that one has to work on both sides. One has to work on it on the side of laboratories, to make them heroes if they transfer technology; and on the side of industry, especially the older industries, to convince them that science and leading-edge technology is in fact the key to their competitive future.

Representative **Lungren**. Just one further question I have is, if the Japanese or other foreign companies are seeking this information, it is there for people to obtain. If there's a shortcoming in the process somewhere on the side of our own industry, and I guess that's one of the questions that's posed, how do we increase the awareness of this opportunity and these resources for technology transfer within the Federal laboratory system? Do you feel that the information mechanism we have is sufficient; that is, the National Technical Information Services mechanisms?

Mr. **Miller**. If I could address that for a moment, I don't know if anybody is still here from the Department of Commerce who could back me up on this, but I was told last week that the largest customer of NTIS reports is Soviet Russia. That's sort of common knowledge. I then was told that the second largest customer of NTIS reports was Mitsubishi Corporation. I think perhaps that's sort of indicative of the role that NTIS plays with U.S. industry.

Representative **Lungren**. So we are doing a good job with regional development in other parts of the world?

Mr. **Miller**. Yes, sir.

Representative **Lungren**. Professor Malecki, you mentioned the sort of oasis concept and the reinforcement of already existing infrastructure that may be performed by these Government laboratories, but one of the questions I have deals with the Midwest. The Midwest has a rich tradition in universities, well-established universities, some established for much longer periods of time than those we have in southern California or throughout California and in some areas of the Southwest where we have some of these areas of research development now coming to pass.

They have large corporate laboratories, many corporations for a long period of time have been involved in those areas of the United States with large urban environments. Why has—or maybe I misunderstood your testimony, but from the tenor of your testimony it appears that this region has been unable to generate significant spinoff from their Government labs? If in fact that is a conclusion that you have reached, do you have any clues as to why that's the case?

Mr. **Malecki**. Yes, I think there are two components to it. One of them is that the industries are the wrong industries. The industries in the industrial Midwest are largely what we now call smokestack industries, a phrase I didn't hear until about 3 or 4 years ago at all. They are largely smokestack firms which, as has just been mentioned, rarely are interested in technology at all, but certainly not the technologies of the type coming out of basic research of Government labs. That's one part of it.

It's this mismatch of interests that the firms that are nearby, that are close to these very vibrant university environments and that are in close proximity to Federal labs, are in essentially the wrong mind set to mesh together in the way that would promote technology transfer in the sense of economic development.

Representative **Lungren**. Well, you talked about Route 128 up there in Massachusetts. If you were here in Congress 10 years ago or 12 years ago you would have heard the outcry of the textile industry going down the tubes and the shoe industry going down the tubes. Those were not smokestack industries, but they were similar in their rapidity of decline in terms of their relationship with respect to the entire economy. You don't hear that any more. Now you talk about the fact that it's—I guess they don't like to be called another Silicon Valley—it is an area of vibrant activity. It did have the universities. But the Midwest had the universities.

Is there any reason why that can't be replicated in the Midwest and that the Government labs can't play a significant role?

Mr. MALECKI. There's no reason, but what I would want to emphasize is that it wouldn't happen in very many places. It probably wouldn't happen in more than two or three places in the whole of the industrial Midwest. Pittsburgh is a metropolitan area that is likely to be one of them because of the research at Carnegie Mellon, because of a large amount of research, the names of which in the scientific jargon I can't even pronounce, but a large range of tremendously important research for the future, for as you say 20 years down the line, has taken place at some of these universities and at a high level that would match that that would take place at Harvard, MIT, and Boston University in the Boston area. It takes this agglomeration of researchers on like topics, not necessarily the same topics.

Let me get back to the second reason why I think the industrial Midwest has not been a seed bed, let's say, of entrepreneurial research activity. One of the main problems is that both the Federal labs are not the largest of the Federal labs. The largest labs tend to all be around Washington, in California, in New Mexico in a few isolated cases. The smaller labs are the ones that are in the industrial Midwest. Even Argonne National Lab, one of the fairly large engineering labs, is really not big enough to make a dent in the Chicago metropolitan area.

In a recent informal study I did for a group of businesses in the Chicago area, they were despairing over the fact that here's this tremendous university 100 miles downstate from them in Champaign, IL, that had no effect on the Chicago metropolitan area in spinning off new firms that would be able to grow within the Chicago infrastructure, in a metropolitan area that would normally be a place where it would be as important economically as San Francisco or Boston. So there's a gap here, a geographic gap, of sometimes 100 miles and sometimes even more that makes a great university in a State have no effect on the metropolitan area that's perhaps 100 miles away and vice versa. They need to be in the same place.

That's the unique thing about the Boston and the San Francisco Bay area, that massive metropolitan complex. Austin could be a small version of one. Albuquerque could be a small version of one.

Representative LUNGREN. Colonel Theuer, maybe you could give us your insight, being from the Midwest.

Colonel THEUER. Let's start with the midsixties. When USA-CERL was established as a laboratory in the midsixties—the criteria for selection was published and 50-plus institutions submitted their bid. The University of Illinois was selected for several reasons and I will list three or four of them here.

The Corps of Engineers was looking for a strong engineering school, one that was closely attuned to the mission which I read earlier, one that had a strong capability in construction management and in computer technology, and had a strong graduate college and technical library.

About 36 percent, roughly a third, of our technical capability is obtained from the university community. We were designed to be university affiliated, and have a large flavor of academia.

The second effect that the laboratory has had on the university is in the attraction or recruitment of faculty to the University of Illinois. We recently had a gentleman from Harvard join USA-CERL and the University of Illinois. He came to Illinois with tenure as an associate professor. His reason for deciding on the University of Illinois was because he would have the opportunity to work with my laboratory. We have many faculty members from several universities on a shared university-laboratory contract basis. We have people at USA-CERL on a 50-50 basis, that is, 50 percent university and 50 percent USA-CERL.

So we, with the university community share a "magnetism." Indeed, we complement each other in many ways.

In terms of the State, the State of Illinois, Governor Thompson's office primarily, has come to realize that there's a capability out there in the university community and in the last session legislation was passed that puts the university at the focal point of providing assistance and startup and grant money for the provision of facilities, for the startup and/or expansion of high tech industries. Initial implementation of the legislation is for medical-related research activities. The spirit of the legislature recognizes the technology coming available from the university and the use of that technology to bring industry into the State and to aid industry already there by emphasizing the university influence in State economic development.

So the university now has a role and it's becoming the base, in effect the drawing card to bring industry into the State and into the region immediately around the university.

Representative LUNGREN. You mentioned the first two patent licenses that took place with respect to the Army and both of them involved going to corporations in the Midwest, one in Niles, MI, and one to Dayton, OH. You mentioned that you developed it with testing done on the M1 tank in Ohio as well.

Are these just aberrations that we have of these two patents or is this something we expect to see more of as a direct spinoff from your operation from patent licensing?

Colonel THEUER. Those are the first two. We have one additional item which is in the corrosion area, a corrosion monitor, that's currently patent pending, and as soon as the patent is received in hand we will then explore and proceed with patent licensing.

I might point out, as was noted earlier, we in effect—I'll use the term in quotes—"protect" the industry involved by issuing an exclusive license. So that any investment that industry makes is in effect protected from its competitors and it's recognized. That's why it's in the Federal Register, so that anyone wishing to appeal or contest that arrangement can do so. So there is a public announcement.

So the answer to the question on patentable items is yes. The answer on nonpatentable items is also yes. We're using the medium of the Commerce Business Daily to announce what we have. It's not patentable as such and we are looking for a manufacturer because we've had calls from both the Army and the Air

Force asking to use this device. The device I am talking about is a "Voice Activated Inspection System."

Representative **LUNGREN**. Let me ask you this. I don't know if you can answer this. Where would you say we are in terms of implementation of the Stevenson-Wydler Act, not just limiting it to that, but the major purpose of the Stevenson-Wydler Act? In your operation, are we ten percent along the way where we want to be in terms of access to technology that you develop? Are we 50 percent of the way? I'm not talking about number of patents out, but in terms of where you would like to be and where you think we could be in terms of technology transfer. Are we just beginning that or are we pretty well along the line?

Colonel **THEUER**. Let's use the term, sir, degree of attainment. No. 1, the authority to transfer technology. I haven't heard too much about the real importance of that The real importance of that cannot be understated. There is the authority to physically give out the technology. You ask and it can be passed out. That's fact one.

The degree of attainment long preceded the Stevenson-Wydler Act of 1980. There are four laboratories right now in the Corps of Engineers. Each one of them has been guided by the following in terms of published results, in terms of deeds, in terms of physically doing things for other Government agencies and for the private sector: published reports, passing of technology to industry, working cooperatively with industry, and perhaps the easiest one to see is the software systems that are operated through service centers in terms of equal access to unclassified systems, equal access to Government operations—I don't care if they're States or other agencies—or the private sector.

So the Stevenson-Wydler Act in effect has formalized that aspect. There's always been a large amount of involvement. We have assisted municipalities with specific problems. We are working with the league of public administrators and city managers in the State of Illinois. We are working with our sister city in Champaign. Other laboratories have done similar things. In a formal sense, each of our laboratories have an ORTA. Each of them have designated persons who reach out, so to speak, on a "push" basis by attending meetings, working with local communities, becoming professionally involved, both in the Government sector, local and State government, and in the private sector.

There's also been an awful lot of publishing. For example, in a recent article in the Engineer News Records, the accomplishments of the Waterways Experiment Station, one of our sister labs, were reported. The Engineering News Record Article addressed the use of the "sand grid system," an expedient type of treadway being used by a construction industry in Alaska. Thus, the products and accomplishments of the labs are not only reported by our people publishing—and that's really the biggest way we get the information out, the individual publishing of specific accomplishments—but major industry and trade publication solicit information from us, as well.

A case in point. You've heard about CERL. We have an experiment station with really a single capability that does a lot of hydraulic work. They do work throughout the United States in the inland waterway system, do a lot of modeling of hydraulics, and most major city works construction efforts are modeled to check them out, to verify calculations often before these works are actually constructed. The cold-region laboratory does an awful lot of interaction through technology transfer. The construction of the Alaska pipeline is an excellent example. Our cold-region lab in this instance had technology that was otherwise not available elsewhere in the United States.

Our labs capabilities represent in many cases a unique capability that often times doesn't exist in the private sector.

Representative LUNGREN. Thank you.

Mr. Dacey, where would you say we are in terms of from your perspective implementing the spirit of Stevenson-Wydler Act?

Mr. DACEY. Well, I would agree with what Colonel Theuer said about being pretty well along that road already before the Stevenson-Wydler Act came along.

My impression of what Stevenson-Wydler has done is to put more emphasis on technology transfer, to make a more formal—shall I say—implementation of funding; that is to say, set aside a half percent of your funds for technology transfer specifically; to require reporting in the larger places to have a technology-transfer officer, as we have at Sandia. His name is Bob Stromberg, if any of you want to get more information from him about this.

But I don't think it addressed many of the other problems we talked about today: Problems of incentives, problems of proprietary interest, problems of transfer to large industry instead of small industry. I think that as far as Stevenson-Wydler went, it was a good thing. I think that it has at least, as I think Professor Malecki said, focused on the problem and made people aware of it.

One of the reasons for having such hearings as this one, I suspect, is that the nature of the problem becomes better understood than it was before.

But, in my opinion, the Federal Government can go further in legislation which stimulates domestic technology transfer.

Representative LUNGREN. Mr. Miller.

Mr. MILLER. I think I'm mostly in agreement. I don't know whether to say the glass is almost filled or partially empty. There were indeed before Stevenson-Wydler pockets of excellence that were essentially performing well in these areas that the law intended. The Army Corps of Engineers is notable and many of the national laboratories, and certainly NASA and many of the agricultural research stations.

But there's been also some evidence of a retrogression from 1980 to the present in certain of the non-Army defense laboratories where there's been a lessening of emphasis on the laboratory level in terms of level of staffing.

So along with the good news, there's some bad news; but I would say it hasn't been fully attained but it's largely attained, perhaps the glass is 80 percent full.

Representative LUNGREN. Professor Malecki, as I understand it, you believe that the Federal labs do not produce the primary prospect for innovation and technological progress in the country with respect to spinoff, but I gather from your testimony you don't think it's an insignificant contribution that they make to innovation and technological improvement in the private sector?

Mr. **Malecki**. Sure. Obviously, the mission of the Federal laboratories is not to promote regional economic development or to spinoff new firms or to create commercially applicable innovations. None of those is the mission of any of the labs that I'm aware of. In fact, they're very far from the mission of most. But each of them has a significant impact on its region by bringing in a different set of people than would be employed and resident in that area otherwise.

In the regions where there are other researchers, engineers, scientists, other innovators, they add to the entire aura of innovation. The whole topic of innovation is one cloaked in mystery and in fact one of the prominent authors on this topic, Nathan Rosenberg, recently wrote a book called "Inside the Black Box," on the topic of innovation in which he said some of the things we don't know. But some of the things that we do know is that innovations, whether they come out of Federal labs or anywhere else, are likely to create the kinds of regional inducements for economic development in major places more than in smaller places, in areas where there is a variety of people, variety of research and educational activities that we find in the larger places. Unfortunately, we focus on Route 128 and Silicon Valley. Perhaps it would make sense to make more studies of the smaller areas. The few that have been done don't tell us very much.

Representative **Lungren**. Your testimony reminds me of the situation we are dealing with in the medical profession. If you want to know why you don't have highly super specialists in some small little town where there's nothing else, it's because individuals of that sort by and large like to have regular communications with their peers and do enjoy some of the things that you mentioned. They like to be close to universities and things of that sort, and I guess it's not surprising in the field of innovation and entrepreneurship as well as in Medicare.

I want to thank all four of you for taking time to be with us. As I say, this is going to be a series of hearings on the whole question of innovation and entrepreneurship and how that fits into our efforts to increase economic growth in this country, and we wanted to make sure that we didn't overlook the area of Government labs. I assure you we are not trying to say that the whole effort is to be placed on the shoulders of Government labs. That would certainly be inappropriate, but it also at the same time ought not to be overlooked, and I think your testimony has helped us to begin to take a look at it from the perspective of the overall hearings. I want to thank you very much.

The committee stands adjourned.

[Whereupon, at 11:55 a.m., the committee adjourned, subject to the call of the Chair.]

STATE INNOVATION STRATEGIES

THURSDAY, AUGUST 9, 1984

CONGRESS OF THE UNITED STATES,
JOINT ECONOMIC COMMITTEE,
Washington, DC.

The committee met, pursuant to notice, at 10 a.m., in room 1310, Longworth House Office Building, Hon. Daniel E. Lungren (member of the committee) presiding.

Present: Representative Lungren.

Also present: Charles H. Bradford, assistant director; and Robert Premus, professional staff member.

OPENING STATEMENT OF REPRESENTATIVE LUNGREN, PRESIDING

Representative LUNGREN. Good morning.

Many States and regions are experimenting with new approaches to spur economic development. They are beginning to recognize that innovation offers a more promising path to economic development than perhaps their old job pirating strategies. Innovation expands the region's economic base and modernizes existing industries by lowering cost and improving product quality, and innovation holds the key to competitiveness, job creation and the future health and prosperity and health of the Nation, as well as its regions.

In the past, the entrepreneur and the development and application of technology to American industry have all too often been ignored, particularly on the Government level, especially here in Washington.

Fortunately, the new wave of State innovation strategies that we're experiencing has brought them back into the forefront of national and regional public policy discussion.

Today's hearing will focus on what actions State governments are taking to encourage entrepreneurship and improve their climate for innovation. In particular, those State actions aimed at removing technological, labor market and financial barriers to innovation will be explored. These actions of States, when viewed individually, could by some seem insignificant, but in their totality, they represent a significant and welcomed effort to improve the Nation's environment for entrepreneurship and innovation.

The factors behind the new tech movement, as the State innovation strategies are often called, will also be explored.

Are the States now looking inward to targeting the process of innovation, or is this just an illusion? Have they really given up their smokestack chasing or job pirating practices? What is the Federal role, if any, in promoting State innovation strategies? The committee is interested in seeking answers to these and related issues in today's hearing.

This is the second in a series of nine Joint Economic Committee hearings on the climate for entrepreneurship and innovation in the United States. I just might say that often times we are supplied with many charts and esoteric arguments by economics as to what makes the economy move, but too little of the attention is given to what makes people move and how we can encourage their ingenuity and their imagination in the spirit of entrepreneurship.

The witnesses before us are well qualified to speak on the subject. Governor Matheson of Utah and Governor Thornburgh of Pennsylvania, States in the forefront of the recent high tech moment. Mr. Beilman of North Carolina will speak on what his State is doing to encourage innovation. North Carolina with its famed Research Triangle Park has a long established record of successfully encouraging high-tech development. And finally, Mr. Brennan will share his expertise, which he gained through numerous interviews with entrepreneurs and State development officials, on what motivates entrepreneurs to locate in certain areas to develop their innovative company.

Gentlemen, we welcome you to our hearing today. We look forward to your testimony and to the question and answer session that will follow.

I would now have Governor Matheson and Governor Thornburgh give their presentation. I would mention that your prepared statement will be made a part of the record, but you may proceed as you wish.

STATEMENT OF HON. SCOTT M. MATHESON, GOVERNOR, STATE OF UTAH

Governor **Matheson**. Thank you, Congressman Lungren.

It is always a pleasure to have the opportunity to appear before the Joint Economic Committee of the Congress, and I am particularly pleased to be invited to share the discussion in one of your nine hearings on improving the climate for innovation and economic growth. It's also a pleasure to share the discussion this morning with my friend and colleague, Dick Thornburgh, from Pennsylvania. We seem to run into one another often these days, and it's a pleasure to appear with such an outstanding Governor as Dick.

I'd like to take just a few minutes to summarize the prepared statement which you have received into the record, Congressman Lungren, and each of us will, I'm sure, present some perspective of the efforts which I'm sure each State is pursuing to find ways to innovate and improve their economic climate in their respective States.

And I think it is fair to say the competition these days among the States is about as intense to attract the kind of business we're talking about, as I can remember, and every Governor is spending a great deal of his time to attract, develop, and nuture that kind of business. And it has not always been thus in the State of Utah. We were pretty much asleep, in terms of economic development, until Gov. Calvin Rampton was elected Governor 20 years ago, we really did not have an aggressive promotion of economic and industrial development in our State.

He recognized, however, in 1965, that whenever Kennecott sneezed, the economy of the State of Utah fell to its knees. And I remember a 6 months' strike in our State during the time that he was Governor at Kennecott and the economy of the State literally came to a standstill. He recognized that you simply can't rely on one or two industries to provide the continuing economical race, when the problems of growth continue to face the State, particularly in Utah, where we have but one interesting fact that no other State can claim. We have the highest birth rate of any State in the United States. As a matter of fact, it's twice as high as the national average, and I was looking at some statistics the other day, and I see no reason that we will not continue in first place in the years ahead.

But Rampton realized that we simply had to start changing the historical approach to the way we managed our economy, and he decided that we needed to get into the diversification, and that has simply been the means by which we've been able to survive. For example, I mentioned that copper was our mainstay. We're a State that grew up with minding hard rock metals. And I just presided over the next stage of Kennecott laying off an additional nearly 2,000 employees within the last few weeks. I remember when they used to have nearly 7,000 employees. They're now down to about 2,000. So we've decided that no single entity or single approach can do the job in the States any longer. And we had to link our research to our development, our education and our training into development and a cohesive strategy was the only way we could proceed.

We also discovered the partnership concept between the public and private sectors, which is now very popular, but we've been working on that for a long, long, time. The record has been a successful one, and I've attached to my testimony a list of the industries that have come into the State and their impact on jobs since I have been Governor. And the way we have had to develop our economic base in our State to keep up with that massive growth which I mention, is to target potential industries and companies for expansion. We simply can't go out with our limited resources and have a successful impact by attempting to do a generic approach to innovation and technological growth.

Now in doing that, there are always many barriers to overcome. There are financial barriers, labor market barriers, and it is a tough challenge. But our goal has been to improve the climate, and to do that we simply have to go out and show the people of the country what we are offering.

Now we have approached it both in a traditional way as well as in a nontraditional way. The traditional approach which we have followed involved exempting the tax on inventories in transit, to begin with, but then we eliminated the inventory tax in our State altogether, and now we are called, as many Western States, a free port State. And anyone who wishes to bring their goods into our State can store them there for a year and not pay any taxes on those goods. And if they take them out within that year's time, they pay no taxes at all. And the common carriers have now devised a transportation concept whereby you only pay one freight rate from your origin to your ultimate designation outside the State of Utah. That has revolutionized the State of Utah, in terms of transportation opportunities, and thousands of jobs have come in, for that reason.

We then enacted a research and development tax credit, and we're currently considering the elimination of sales taxes on new manufacturing machinery. I have the interesting experience of dealing with a company that makes diapers. Incidentally, that company has found a ready market in the State of Utah for that product. [Laughter.]

But that company is interested in having the machinery that makes the diapers exempted from the sales tax, and if we are going to be competitive, it turns out that all of the States surrounding us already have exempted that machinery. So I am looking at the possibility, in a special session, of exempting that sales tax.

We then developed a capital budgeting system in the State of Utah. I might suggest that for the Federal Government it is not a bad system to use, and we have found that that has had a profound impact on the way that financial experts look at the State of Utah. They look at the way we do our budgeting, and when we went to the capital system 3 or 4 years ago, we inched up our credibility in the financial markets dramatically. Now that has really, on a traditional basis, helped us dramatically.

But in a nontraditional way, we've attempted to try and find techniques that would really aid in the innovative and technological field. For example, we have a small business revitalization program which we have inaugurated for small business in the State. We were the first in the Nation to participate, and we have more small revitalization program loans and grants in combination now than any other State in the Union.

I was very interested in pursuing the support for high technology ideas by taking an idea and converting that into a small company and developing it, and to show our intent to do that, I submitted a bill to our legislature a year ago in January to create a Utah technology finance corporation. That's a high sounding phrase to create a public corporation, served with a board of directors made up of private citizens who are experts in the field. We appropriated some funds. Secretary Pierce helped me with some additional funds. And they examine ideas and put equity money into that corporate opportunity. We don't manage the company, and if it's a success, we take our equity back. If it fails, we go on to the next idea. But that, as seed money, is becoming a means by which companies that can't otherwise get the funding, have been able to start their new businesses.

We then passed another item of legislation earlier this year called "Privatization." We are now able to bid sewage systems, for example, and transportation of sewage systems, out to private entrepreneurs. We are now instead of going out and bonding, going on bids. Private companies are coming in and doing the traditional governmental services, and we're finding that the cost of doing it through the privatization approach is startlingly lower than the traditional ways that we've been putting those businesses forward.

We then amended our State retirement fund statute to allow our retirement board to invest in venture capital pools. We're starting out with a small $20 million program, and up to now, the investments they have made have shown tremendous promise.

We also allow State tax credits to encourage research and development.

Just to give you some of the ideas of nontraditional ways that we have attempted to attract and develop a broader base for our high technology opportunities in our State.

We have found that labor availability and skills are critical factors in regionalizing the location of high-tech companies. We certainly realize that if we are going to be successful, we are going to have to sustain our higher educational commitments. In fact, the only reason we have any success at all in high tech is because 25 years ago, we invested heavily in research in our three universities in our State and we are now reaping the rewards of that 25-year investment with interesting and productive concepts. For example, we have used—during the economic downturn of the past few years a good share of our Federal mineral lease royalties, and we single out one of the disciplines on one of the campuses. For example, the mines and minerals department required a new buiding, and we set aside mineral lease money to put together the necessary capital formation to construct the new building which, in turn, precipitated research grants into that department equal to about double the cost of the building, the first year.

I did the same thing to build a new chemistry building, and as a result, we now have the third best chemistry program, I am told, in the United States.

We did the same thing for engineering up at Utah State University.

In other words, we target those limited funds to the areas which will produce the opportunities in the innovation and high tech field.

Last year, 1,000 undergraduates and 5,000 graduates, from our Utah universities and colleges, received degrees in engineering and computer science. We are continuing to highlight the areas which will produce the people that are required in the field we're discussing. I might point out that while we are doing that, our neighbors are certainly not sitting idle.

My good friend and competitor in Arizona, Bruce Babbitt, has decided he wants to have the best engineering school in the United States down at Tempe, and so he has put a $30 million program into engineering and has actually taken funds away from other traditional sources on the campus. In fact, I was talking to the dean of the law school, and he was very upset about it, because they took some of his legal funds away to put it over in engineering. And he's pretty serious about it, and I know it, because he happens to be a brother. [Laughter.]

And he didn't have a kind word for Governor Babbitt. But the dean of the engineering school is absolutely delighted.

The net effect of all that is that we are all competing to get the training in the areas that will feed the innovation area, the subject of this discussion.

In terms of public and private initiatives, we have a science advisor and a State advisory council on science that examines new concepts and ideas to advise both the Governor and the legislature. And in that area, we have utilized the research which has been going forward on the campuses for many years to our advantage. For example, we have a department of bioengineering which I think probably produces more new ideas for new products than almost any other discipline on the campus, and as you know, we have become the national center for artificial organ research.

In addition, the University of Utah has an interesting office; namely, the patent and product development office that helps transfer new products to private use. And when they agree to take something to patent, they take a small equity interest in the company, and the university has been able to license 20 small startup companies just since 1981. And I am not aware of too many States that have that capacity in the university level It has been very effective for us.

We also have developed at the University of Utah a very sophisticated research park. It has 17 buildings and represents an investment of about $85 million with 3,000 employees now. And now we're designing the opportunity for a research park at the Utah State University at Logan. The mission of those universities and colleges is committed in a dramatic way to a research priority, and some people are concerned that maybe if we go too high into research, we are not addressing the traditional role of those institutions.

If anybody would examine the economic impact those institutions have in the State, they would realize that they produce jobs and income and taxes, and that the research is a major way that we spinoff in the ideas that create these new high tech jobs.

Two other points. Regulation. We continually in public life get nailed with the fact that we overregulate private industry, and every Governor commits, when he goes into office, that he is going to reduce bureaucratic regulations. I am sure that Dick has experienced that, and I know, Congressman, that comes to your attention constantly about the Federal bureaucratic machinery. I can assure you that machinery exists at the State level as well.

But there is an answer to that, in my opinion, and it is time for us, I think to put that in this perspective, if we're going to have that aid in the development of high tech industries in our State. We all want to deregulate as much as we can. And my theory is that we have to do some regulation, and so I entered into a partnership—got a piece of legislation through the State legislature, and we enter into an agreement with the business that is regulated, and we jointly sit down, and we work out what we think is the appropriate level of regulation for that industry. And we have found that the industry itself wants some regulation. But if you sit down with them and help decide what is in the public interest and jointly negotiated that with the business entity itself, you end up having a regulatory atmosphere that, in my opinion, is much more successful.

We have found, finally, that the public-private cooperation concept that has been banted around so much the last few years really does make sense. We have found that whenever we have a prob lem, the Jobs Training Partnership Act is a good example of how the public-private partnership can really work. But we have attempted to do that in every area where the impact of the State government falls upon private business and we have found that by doing that kind of an interface that we are able to solve our problems much more dramatically and much sooner.

I think it's fair to say that we are very competitive in terms of establishing a climate to innovate and to develop the proper economic growth in our State. It's not fair for us to be placed in the same category as Silicon Valley or North Carolina and other States which have great reputations. But we are a solid, committed State in the field and over the years have been able to develop a successful and innovative program, and this will continue.

We are very pleased to be a part of the opportunity to present those views to you here today, Congressman Lungren, and I will be very happy to respond to questions whenever you get around to that part of the program. Thank you.

[The prepared statement of Governor Matheson, together with an attachment, follows:]

Prepared Statement of Hon. Scott M. Matheson

STATE STRATEGIES TO IMPROVE THE CLIMATE FOR INNOVATION AND ECONOMIC GROWTH

Chairman Lungren, Senators and Representatives of the Joint Economic Committee, I appreciate the opportunity to present testimony here today on the subject of Utah's strategies for improving the climate for innovation and economic growth. We believe that the state of Utah has developed some creative and effective programs in this area and I hope that succeeding administrations will continue to build on our efforts. We have, through practical application of these innovative programs, attracted new industrial development to Utah, and I am pleased to present some of our experiences for your consideration here today.

BACKGROUND

About 20 years ago, under the leadership of Gov. Calvin L. Rampton, the state of Utah began to aggressively promote economic and industrial development. It is important to emphasize at the beginning that Utah is somewhat unique in its economic development needs. As you may know, our population rate is the highest in the nation. Obviously, we need to provide jobs for our citizens, and under the circumstances, we must provide them at a very high rate of increase.

Gov. Rampton made some exceptional progress in infusing the state's economic development effort with new programs and ideas. In the years since I took office, we have realized that Utah's economy must be diversified. For example, the copper mining and refining industry was considered for many years to be one of the mainstays of our economy. As you probably know, the copper industry is troubled these days. Kennecott Copper Co. recently laid off nearly 2,000 employees in Utah. A well diversified economic base helps us absorb shocks like this.

Diversification also helps us survive some of the major problems over which individual states have little control. An example is the monumental deficit under which our nation currently is struggling. The overall deficit problem, and more specifically, high interest rates and trade deficits, have serious negative implications for our international trade efforts.

There is no single governmental entity, nor any single approach that provides the total answer in our quest for diversity in economic development. I believe that statement would apply to any state with similar goals in mind. States must adopt comprehensive approaches linking research and development, education and training, and small business development into a cohesive strategy. A recent report from the National Governors' Association suggests that "broad, multifaceted, comprehensive approaches provide the best opportunities for actualizing state potential for technological innovations." Infrastructure development, education reform, manpower training for displaced workers, state and federal support of research, financial management assistance, and strong partnerships between the public and private sectors are all integral parts of successful state plans to bolster economic development.

I believe the record shows that we have been quite successful. We have developed a creative national campaign to promote the advantages of our highly educated and productive work force, our abundant natural resources, and our positive business climate. Our initial efforts were directed simply at bringing in new industrial activity, but over the years we have become more knowledgeable, putting into place a sophisticated research effort designed to gather relevant economic development data and to target potential industries and companies for expansion in Utah. For example, we were one of the first states to do target studies and marketing on high growth technology companies and companies needing to expand office space.

OVERCOMING THE BARRIERS

You have asked for my comments on how Utah is overcoming financial, labor market and technological barriers to innovation in high-technology growth. This is a tough challenge and it is not solely a state responsibility. It requires the closely coordinated efforts of federal, state and local governments, and the private sector. Attacking these barriers, the state has made a concerted effort over the years to not only improve Utah's business climate, but to make it among the best in the nation.

We have tried to do this by utilizing both traditional and non-traditional approaches. Our traditional activities have emphasized tax reforms, and our non-traditional approaches have included the creation of some innovative new programs.

THE TRADITIONAL APPROACH

With respect to financial initiatives, we review the state's tax structure each year to keep it in harmony with the needs of economic development. Initiatives in this area have included the exemption in 1967 of taxes on inventories in transit, and eliminating the inventory tax altogether in 1973. In 1974 we convinced the Utah Legislature it would be a good idea to enact a research and development tax credit, and we are currently considering exempting the sales tax on new manufacturing equipment. Our corporate income tax is among the lowest in the nation, and our overall business tax structure, at both the state and local levels, is ranked 48th among the states, according to a recent study by the National Tax Journal.

We also have made a strong commitment to make substantial investments in our public infrastructure by developing a capital budget system. These coordinated investment strategies have served well to support our long-range economic development objectives, and we expect they will continue to do so.

SOME NEW IDEAS

In the area of non-traditional activity, an important focus of the second term of my administration has been the identification and implementation of various policy initiatives designed to enhance the availability of capital for private sector economic development, and to find solutions to the long-term financing gaps faced by our small business entrepreneurs.

These initiatives include a Small Business Revitalization program, creation of the Utah Technology Finance Corporation, enabling legislation for the privatization of some public services, legislation to allow the State Retirement Fund to invest in professionally managed Utah venture capital pools, and state tax credits to encourage investments in research and development partnerships.

SMALL BUSINESS REVITALIZATION PROGRAM

Utah was one of the first states to participate in the federal Small Business Revitalization Program which makes SBA 503 loans and Urban Development Action grant funds available to the states. We have just entered the third year of participation in this program, and of the 34 states now involved, Utah ranks first, on a per capita basis, in the amount of money placed with small businesses.

THE UTAH TECHNOLOGY FINANCE CORPORATION

The Utah Technology Finance Corporation encourages and assists the establishment and growth of new high technology business in Utah. The corporation has received money from both public and private sources, including federal and state funds. Its trustees include representatives from the private sector, university and public officials. The corporation will continue to concentrate on developing home-grown business in Utah by providing seed money in several important areas.

These include research contracts, program grants, equity investment, convertible loans and venture financing. The corporation will, in effect, be a revolving account where money is invested and reinvested.

The corporation, created in 1983, will provide start-up money and receive royalties on successful research, or take a position which will allow for conversion into equity at a later stage. In some cases the corporation will make direct equity investments.

It has also resulted in a State Small Business Innovation Research Program similar to the Federal SBIR and will provide research and development finance to meritorious applications only partially funded by federal programs.

LABOR MARKET BARRIERS

With respect to labor market barriers, a study entitled, "The Location of High Technology Firms and Regional Economic Development" was done by your staff in June 1982. It found that labor availability and skills were the most important factors influencing the regional location of high-technology companies. Traditionally, our labor force has been very reliable and well trained. Our colleges, universities and vocational schools will continue to supply trained workers for high-tech industries. Utah has made a significant financial commitment to the development of the related disciplines so critical to the success of high-tech firms. An example of this is our use of the state's share of federal mineral lease royalties for research buildings and equipment.

In 1982-83, Utah's system of higher education awarded 1,000 undergraduate and 500 graduate degrees in engineering and computer science. The University of Utah in Salt Lake City has the largest engineering program in the state. Our major private school, Brigham Young University, which is also the state's largest private employer, has a very successful electrical engineering program, and Utah State University in Logan is actively involved in the nation's space programs.

Utah's four-year bachelor programs and two-year associate degree programs are providing increased training for students wishing to work in high-tech industries. Thus, Utah's four universities and two technical institutions, all located along the Wasatch Front, the 100-mile corridor stretching from Logan on the north to Provo on the south, have been instrumental in meeting the skilled manpower needs of existing high-tech firms in Utah, and in creating employment conditions attractive to high-tech firms seeking new locations. These programs must be expanded, but we have made excellent progress in the area of training.

In addition, the U.S. Department of Labor has funded a pilot program called the Wasatch Front Enterprise Center, to assist new business owners in learning about the labor and management skills they need to put their ideas to work. Associated with the center, the Wasatch Front South Private Industry Council is a cooperative effort between government and private business to train and place qualified individuals in today's dynamic labor market.

The council is composed of a wide variety of business and government leaders who volunteer their time and expertise for the improvement of training and employment opportunities in our communities. Finally, we have attempted to coordinate federal Job Training Partnership Act funds in a way that maximizes training for the needs of new and expanding businesses, and emphasizes jobcreating activities.

I decided to place our JTPA programs under the jurisdiction of the Department of Community and Economic Development to ensure that the resources were coordinated with and enhanced ongoing economic development efforts.

PUBLIC AND PRIVATE INITIATIVES

Utah is also addressing the technological barriers to innovation through both private and public sector initiatives. We have a science advisor and an advisory council on science and technology to advise the governor and the legislature. In addition to the research and development tax credit, the state's university system provides a research environment which fosters a mutually beneficial partnership between the university and high-tech industry. There are numerous examples of the academic community's dedication to collaboration on research and technology, and a good one is the College of Engineering at the University of Utah which has become a center for high technology research. Government and private funding for this effort totals $8 million annually, and the college is now ranked in the top 20 nationally.

The University of Utah's Department of Bioengineering has become a national center for artificial organ research with such developments as the artificial heart, eye, ear, and the wearable kidney. Research is also being undertaken in electronic diagnostic monitoring and theraputic devices, as well as on biocompatible materials. Other high-tech areas of emphasis include research into composite materials and computer interactive applications.

Beside providing facilities to develop technology, both Utah State University and the University of Utah have established effective channels to transfer new products to private use. The University of Utah's Patent and Product Development Office actively recruits firms to license university technology. One unique aspect of the university's program is that it will accept equity interest in a company as payment for a license. Through this strategy the university has made it possible for 20 small start-up companies to obtain licenses since 1981.

The University of Utah has also developed a research park to facilitate the interaction of university knowledge with industry. A critical factor in establishing the research park was the willingness of the military to declare certain undeveloped land near Fort Douglas, which is located adjacent to the campus, as surplus, and allow for the transfer of the land to the university following a pattern set in 1951 by Stanford University's research park. A management plan was developed to provide a carefully thought out physical environment to promote private sector high technology activities. Since 1970, 17 buildings have been completed and occupied.

The park currently represents an investment of more than $85 million. Three thousand employees are involved and their payroll of more than $100 million annually is a significant factor in Utah's economy.

One of the residents of the park is the Utah Innovation Center. It was established in 1977 with funds from the National Science Foundation. The primary purpose of the center is to develop start-up high technology companies. In return for an equity position, or a share of interest in a firm's technology, the center provides venture capital, management assistance, technical library office space, and secretarial and legal services. Since 1982 when federal funding ended, the center has become a private firm consistent with NSF's hopes that it would evolve into a self-sustaining entity.

At Utah State University in Logan, plans are underway to begin construction of a research park and a branch of the Utah Innovation Center. Recent successful spinoff from USU's research includes the development of small, inexpensive communication satellites launched from the space shuttle, the development of infrared instrumentation which grew out of a contract with the U.S. Air Force, and integration of computers to diagnose and provide interactive training for the handicapped.

John Naisbitt, an advisor to firms on business trends and the author of the best-selling book, *Megatrends*, has identified Salt Lake City as one of the ten "new cities of great opportunities." He notes that its strategic resources are brain power and quality of life. In my 1983 State of the State address, I observed that fundamental changes in the job market are transforming both the worker and the work place. High technology companies depend on intelligence as their raw material rather than access to new markets, energy sources or climate. I believe Utah is uniquely situated to benefit from emerging economic trends. Our quality of life has been, and will continue to be, a key factor in attracting and retaining professionals in high technology companies. Our colleges and universities, the research park, and the innovation center, provide an intellectual nucleus where ideas flourish.

I do not believe there is any danger that the academic mission of Utah's universities and colleges will be overshadowed by their economic research and development efforts. Associate Dean Robert E. Stephenson of the University of Utah's College of Engineering says that cooperation on research of joint interest to the university and to industry are mutualy desirable and are to be encouraged. However, it is important that the federal government and the states continue to preserve the spirit of basic research which, in the end, provides the basis for most technological ideas.

COPING WITH REGULATIONS

Another matter of concern to us has been the regulation of business. It is no secret that many in the world of business and industry would like to see drastic reductions in regulation, and government has usually responded to these requests by talking in terms of regulatory reform and/or deregulation. The track record shows that neither effort has been very successful.

The failure of most regulatory reform efforts can be attributed to the unrealistic premise that regulation is unnecessary. On the contrary, some regulation is necessary. Therefore, the challenge is to achieve effective management by demanding governmental accountability.

In response to the needs of business, especially small business, I supported legislation enacted last year that involves the formation of a partnership between business and government in the regulatory decision-making process. The measure provides, among other things, that agencies may set fees administratively but it requires that the fees must reflect the cost of conducting the action. Each fee is determined by using a simple formula to determine what costs may be passed through. The proposal also provides that business assist government in determining the fee by defining how much regulation is desired.

When we discussed this proposal with representatives of 42 licensed professions and trades they unanimously supported it. Without exception, these individuals stated that this measure would help maintain high standards.

I have also approved an extensive training program for state agency personnel which focuses on the role of the executive branch in the regulatory framework, particularly in our rulemaking efforts. Beside providing a background in administrative law, the training makes employees aware that rulemaking cannot be done in a vacuum. It is part of a much larger process that begins with the legislature and may end in the courts. Therefore, it must continually review its efforts in order to respond to changing needs and situations.

In addition to the advice available from such groups as the Private Industry Council, the Department of Community and Economic Development assists businesses in dealing with governmental red tape at the local and state levels, and we are attempting to make state agencies more cognizant of the problems faced by small business entrepreneurs.

PUBLIC/PRIVATE COOPERATION

While the role of the private sector in providing entrepreneurial ideas and most of the capital necessary to implement these ideas is still paramount, local, state, and federal government support can make a difference. At the federal level, it is important to continue research contracts and grants, including basic research which provides the foundation for many productive entrepreneurial ideas. I think it is also useful to examine surplus property located near universities which have the capability for developing research parks similar to the one at the University of Utah. The Small Business Administration Innovation Awards are another way the federal government can encourage new ideas. Research and development tax credits and accelerated depreciation also provide incentives for companies wanting to begin, or expand new businesses.

It is also important that states realize their strengths and weaknesses. Utah is not trying to become a Silicon Valley or a Massachussetts Route 128, but we are attempting to establish a reputation as a high-tech center in bioengineering, in medicine, and in certain natural resource areas. We would rather build on our strengths than attempt to compete with all states in all areas of development. We simply do not have the resources to play that game, and in my opinion attempts to do so may prove counter-productive in Utah and any other state that might try it.

At the federal level there is no more critical role for any business expansion, including high technology, than to provide a stable fiscal policy. This, I believe, includes a concerted commitment to reduce existing federal deficits in such a way that interest rates decrease without spurring inflation. No amount of federal money spent to encourage high technology industrial development is more important than the solution of this most difficult dilemma.

CONCLUSION

Again, let me emphasize that the successes we enjoy in Utah are the cumulative results of years of effort by state and local government, chambers of commerce, public and higher education, and many private companies. I believe that our successes can be a model for others, and I hope that other states, through the findings of your committee, will be encouraged to learn from our experiences as we have learned from theirs.

Mr. Chairman, I again thank you for inviting me to present testimony to this Joint Economic Committee. I am also submitting for your consideration supplemental materials regarding some of the activities I have mentioned in my testimony. I hope they will be helpful to the committee and staff.

COMPANY LOCATIONS IN UTAH

DATE	COMPANY	CITY LOCATION	COUNTY	ESTIMATED ORIGINAL EMPLOYMENT	EMPLOYED AS OF MARCH 1984
JAN 77	WEYERHAUSER, INC.	SALT LAKE	SALT LAKE	5	18
FEB 77	TRAVELERS INSURANCE CO.	SALT LAKE	SALT LAKE	150	270
APR 77	OSMOND STUDIOS	OREM	UTAH	120	70
MAY 77	FACET AUTOMOTIVE FILTER CO.	SALT LAKE	SALT LAKE	120	200
MAY 77	BONDATE CORPORATION	ST. GEORGE	WASHINGTON	10	--
MAY 77	VARIAN, INC.	SALT LAKE	SALT LAKE	45	680
MAY 77	ENERGY FUELS	BLANDING	SAN JUAN	20	9
JUNE 77	AGRI-CORP	NIBLEY	CACHE	20	--
JUNE 77	PIPE ALLOY COMPANY	OGDEN	WEBER	30	--
JULY 77	RAYLOC DIV. OF GENUINE PARTS	PAYSON	UTAH	150	96
JULY 77	APPLIED DIGITAL DATA	SALT LAKE	SALT LAKE	1,000	--
AUG 77	BRISTOL FOODS, INC.	CLEARFIELD	DAVIS	250	--
AUG 77	PIPER INDUSTRIES	CLEARFIELD	DAVIS	55	--
AUG 77	BOURNS, INC.	LOGAN	CACHE	300	443
SEPT 77	ACME ELECTRIC COMPANY	SALT LAKE	SALT LAKE	300	150
SEPT 77	WILLIAMS RESEARCH	OGDEN	WEBER	300	425
OCT 77	UTAH CANDY MAKERS	NEPHI	JUAB	20	--
NOV 77	ENERGY RESERVES GROUP	SALINA	SEVIER	200	--
NOV 77	PLATEAU RESOURCES	BLANDING	SAN JUAN	16	--
NOV 77	BURRELLE'S, INC.	PROVO	UTAH	75	200
MAR 78	POLYTEX COMPANY	WEST JORDAN	SALT LAKE	10	--
MAR 78	LA-Z-BOY CHAIR	TREMONTON	BOX ELDER	350	400
APR 78	KIRBY BUILDING SYSTEMS	SPANISH FORK	UTAH	120	90
MAY 78	HOERNER-WALDORF CORP.	SO. SALT LAKE	SALT LAKE	15	--
MAY 78	RIVERSIDE	CLEARFIELD	DAVIS	50	64
MAY 78	CURTIS NOLL	CLEARFIELD	DAVIS	10	--
MAY 78	WESTERN ZIRCONIUM	LITTLE MOUNTAIN	WEBER	450	470
JUN 78	BERTEA, INC.	NO. OGDEN	WEBER	100	155
JULY 78	STONE CONSTRUCTION EQUIP.	PLEASANT GROVE	UTAH	40	17
AUG 78	NATTER MANUFACTURING CO.	WEST JORDAN	SALT LAKE	40	188
AUG 78	ROCKWELL INTERNATIONAL	SALT LAKE	SALT LAKE	500	530
SEPT 78	G.T.E. TELECOM SYSTEMS GROUP	SALT LAKE	SALT LAKE	500	400
NOV 78	CONTINENTAL LIME, INC.	BLOOM	MILLARD	40	33
NOV 78	AMERICAN GREETINGS	BRIGHAM CITY	BOX ELDER	100	190
JAN 79	INTERSIL CORPORATION	NORTH OGDEN	WEBER	250	--
FEB 79	GENERAL BATTERY CORP.	CLEARFIELD	DAVIS	10	--
MAR 79	BOURNS, INC.	OGDEN	WEBER	400	250
JULY 79	NUCOR CORPORATION	PLYMOUTH	DAVIS	250	310
AUG 79	MARTIN MARIETTA CEMENT DIV.		JUAB	300	100
AUG 79	SPERRY UNIVAC	EPHRAIM	SANPETE	100	400
AUG 79	WHEELER MACHINERY	SALT LAKE	SALT LAKE	60	460
AUG 79	STAR DIST. CENTER	SALT LAKE	SALT LAKE	40	--
AUG 79	ASPEN DISTRIBUTING	SALT LAKE	SALT LAKE	50	20

DATE	COMPANY	CITY LOCATION	COUNTY	ESTIMATED ORIGINAL EMPLOYMENT	EMPLOYED AS OF MARCH 1984
AUG 79	THIOKOL	BRIGHAM CITY	BOX ELDER	700	5,600
EPT 79	HERFF JONES	LOGAN	CACHE	150	145
NOV 79	(TSC) TECHNOLOGY SERVICE CORP.	SALT LAKE	SALT LAKE	80	--
DEC 79	RIVERSIDE INDUSTRIES	LITTLE MOUNTAIN	WEBER	200	65
JAN 80	SOUTHWIRE	LITTLE MOUNTAIN	WEBER	250	--
MAR 80	LITTON INDUSTRIES	SALT LAKE	SALT LAKE	400	868
JUN 80	NUCLEAR FUELS	BLANDING	SAN JUAN	125	--
JUN 80	IDEAL BASIC INDUST.	DEVIL'S SLIDE		50	1
JULY 80	ITT CONTINENTAL BAKING CO.	OGDEN	WEBER		350
AUG 80	RAMCO STEEL	SALT LAKE	SALT LAKE	12	12
SEPT 80	GALIGHER ELASOMERS	SALT LAKE	SALT LAKE		250
OCT 80	CONTINENTAL LIME CO.	MILLARD			33
OCT 80	SCOTT PLASTICS CO.				23
NOV 80	EASTON ALUMINUM		SALT LAKE	200	130
DEC 80	R. S. SUPPLY CO. &		SALT LAKE	200	--
	KILSBY TUBE SUPPLY			32	--
JAN 81	AMERICAN EXPRESS	SALT LAKE	SALT LAKE	1,500	1,400
JAN 81	FOREIGN TRADE ZONE	SALT LAKE	SALT LAKE		1
FEB 81	LA-Z-BOY (Expansion)	TREMONTON	BOX ELDER		--
FEB 81	KREMCO, INC.	OGDEN	WEBER	200	20
FEB 81	EKTEK, INC.	SALT LAKE	SALT LAKE	30	--
MAR 81	JOHNSON MATHEY, LTD.		SALT LAKE	100	50
MAR 81	GRAPHIC ARTS PUBLISHING	SALT LAKE	SALT LAKE		4
MAR 81	JOHNSON PUMP CO.	SALT LAKE	SALT LAKE		--
MAR 81	FRONTIER ENGINE	SALT LAKE	SALT LAKE		10
MAR 81	NASCO NORTH CENTRAL	SALT LAKE	SALT LAKE		4
MAR 81	GE LOCOMOTIVE	SALT LAKE	SALT LAKE	20	3
APR 81	VERMONT AMERICAN CORP.	OGDEN	WEBER	60	8
APR 81	THE THREE WAY CORP.	SALT LAKE	SALT LAKE		--
MAY 81	AMERICAN PARTS SYSTEM	SALT LAKE	SALT LAKE	50	15
MAY 81	LONG-AIRDOX CO.	HUNTINGTON		50	83
MAY 81	AIR PRODUCTS & CHEMICALS			35	10
MAY 81	TRI-STATE OIL TOOL IND.	VERNAL	UINTAH	30	6
MAY 81	GOLDEN GRAIN MACARONI	SALT LAKE	SALT LAKE		20
JUNE 81	IOMEGA CORP.	OGDEN	WEBER	200	447
JUNE 81	CROSS COUNTRY PIPE LINE SUPPLY	SALT LAKE	SALT LAKE	15	--
JUNE 81	WEATHER SHIELD MFG.	LOGAN	CARBON	200	250
JUNE 81	VULCRAFT	BRIGHAM CITY	BOX ELDER	260	234
JUNE 81	LONGVIEW FIBRE CO.			10	--
JUNE 81	CHEVRON RESEARCH CO. & CHEVRON SHALE OIL CO.	NO. SALT LAKE	DAVIS		125
JUNE 81	PARAHO DEVELOPMENT CO.	VERNAL	UINTAH		--
JUNE 81	GREAT NATIONAL CORP.	SUNNYSIDE	CARBON		--
JULY 81	PERMALOY	OGDEN	WEBER	200	20
JULY 81	LEEDS & NORTHROP CO.	SALT LAKE	SALT LAKE	200	72
AUG 81	SWINNEY ENTERPRISES	SALT LAKE	SALT LAKE	20	--

DATE	COMPANY	CITY LOCATION	COUNTY	ESTIMATED ORIGINAL EMPLOYMENT	EMPLOYED AS OF MARCH 1984
SEPT 81	BLAZER CORP.	MORGAN	MORGAN	45	--
SEPT 81	TUBULAR SERVICES WEST	SPRINGVILLE	UTAH	255	65
SEPT 81	ONEIDA COLD STORAGE/ CURTIS TRUCKING	SALT LAKE	SALT LAKE		10
SEPT 81	SKAGGS TELECOMMUNICATONS SERVICE	SALT LAKE	SALT LAKE		243
SEPT 81	R.P. SHERER CORP.	SPRINGVILLE	UTAH	200	26
OCT 81	SORENSON DEV., INC.	SALT LAKE	SALT LAKE		100
OCT 81	ROADWAY EXPRESS, INC.	SALT LAKE	SALT LAKE	20-25	70
NOV 81	LEWIS REFRIGERATION CO.	SALT LAKE	SALT LAKE		122
DEC 81	SPERRY UNIVAC MINI-COMPUTER	SALT LAKE	SALT LAKE		50
MAR 82	MCLEAN TRUCKING CO.	SALT LAKE	SALT LAKE	10	40
MAR 82	MASON DIXON LINES, INC.	SALT LAKE	SALT LAKE		--
APR 82	FRONTIER AIRLINES	SALT LAKE	SALT LAKE	100	168
APR 82	A-L WELDING PRODUCTS	SALT LAKE	SALT LAKE		11
MAY 82	RAMRAS SPECIALTY CO.	SALT LAKE	SALT LAKE	25	13
MAY 82	WESTERN AIRLINES	SALT LAKE	SALT LAKE		2,000
JUN 82	EVANS & SUTHERLAND	SALT LAKE	SALT LAKE		700
JUN 82	METAL GOODS SERVICE CENTER (DIV OF ALCAN ALUMINUM LTD)	SALT LAKE	SALT LAKE		25
JAN 83	TALBERT CORPORATION	SALT LAKE	SALT LAKE		
JAN 83	COMET CLEANERS	SALT LAKE	SALT LAKE		
JAN 83	CSI (COMPUTER INPUT SERVICES, INC.)	MURRAY	SALT LAKE	150-200	
JAN 83	ALCO OF DENVER	SALT LAKE	SALT LAKE	20-30	
JAN 83	AMERICAN MICROSYSTEMS	SALT LAKE	SALT LAKE	35-40	
JAN 83	CUSTOM TOUCH ELECTRONICS	SALT LAKE	SALT LAKE		
JAN 83	DELUXE CHECK PRINTERS	SALT LAKE	SALT LAKE	30-35	
JAN 83	DIGITAL EQUIPMENT	SALT LAKE	SALT LAKE		
JAN 83	HARLAND CO., JOHN H.	SALT LAKE	SALT LAKE	90	
JAN 83	MILLER, E. A. (Expansion)		CACHE	700	
JAN 83	RONLEY, INC.	SPRINGVILLE	UTAH	40-50	
FEB 83	HERCULES AEROSPACE DIV. (RESEARCH & DEV. LAB.) (Expansion)	SALT LAKE	SALT LAKE		
FEB 83	METAL GOODS (DIVISION OF ALCAN ALUMINUM)	SALT LAKE	SALT LAKE		
MARCH 83	DHL AIRWAYS/WORLDWIDE COURIER EXPRESS	SALT LAKE	SALT LAKE	60	
MARCH 83	ROME CABLE	WEST JORDAN	SALT LAKE	70	
MARCH 83	UTILIMASTER	OGDEN	WEBER	55	
MARCH 83	VALVE & FITTING, INC.	SALT LAKE	SALT LAKE	15-20	
MARCH 83	U.S. HOME MANUFACTURED HOUSING	SALT LAKE	SALT LAKE	300	
MARCH 83	R. C. BOTTLING CO.	WEST VALLEY CITY	SALT LAKE	30	
MARCH 83	CISI (COMPUTER INPUT SERVICES, INC.)	SALT LAKE	SALT LAKE	90	

DATE	COMPANY	CITY LOCATION	COUNTY	ESTIMATED ORIGINAL EMPLOYMENT	EMPLOYED AS OF MARCH 1984
APRIL 83	MORTON-THIOKOL (Expansion)	BRIGHAM CITY	CACHE	50-100	
APRIL 83	SPERRY (DEFENSE DIV.) (Expansion)	SALT LAKE	SALT LAKE		
APRIL 83	SENCO FASTENING SYSTEMS	SALT LAKE	SALT LAKE		
APRIL 83	SCHENKERS INTERNATIONAL	SALT LAKE	SALT LAKE		
APRIL 83	SALT LAKE CIRCUITS	SALT LAKE	SALT LAKE	35-40	
APRIL 83	B & L MANUFACTURING	PROVO	UTAH	183	
MAY 83	DISER, INC.	OREM	UTAH	30	
MAY 83	THIOKOL (BRIGHAM APPAREL BLDG.) (Expansion)	SALT LAKE	SALT LAKE		
MAY 83	SPECIALTY ENGINEERS			8	
JUNE 83	PEN-TEC ENTERPRISES	WEST VALLEY CITY	SALT LAKE	16-24	
JUNE 83	ROCKY MOUNTAIN BANK NOTE (Expansion)	SALT LAKE	SALT LAKE	106-381	
JUNE 83	UNIVERSAL CONCRETE	SANDY	SALT LAKE	30-40	
JUNE 83	PRIDE ELECTRONIC ASSEMBLIES	SALT LAKE	SALT LAKE	45-150	
JUNE 83	UNITED AIRLINES (New Facility)	SALT LAKE	SALT LAKE	17	
JULY 83	J. R. CONTROLS	SALT LAKE	SALT LAKE	9	
AUG 83	CATHETER TECHNOLOGY	SALT LAKE	SALT LAKE	318	
AUG 83	KASTLE USA			40	
SEPT 83	ENDOTEK GROUP, INC.	SALT LAKE	SALT LAKE	18	
SEPT 83	URS CORPORATION	SALT LAKE	SALT LAKE	9	
SEPT 83	W. H. FREEMAN CO.	SALT LAKE	SALT LAKE	90	
SEPT 83	WELLS CARGO	OGDEN	WEBER	104	
SEPT 83	LEVELOR LORENTZEN	OGDEN	WEBER	1,245	
SEPT 83	ENDOTEK GROUP, INC.	SALT LAKE	SALT L[illegible]	18	
SEPT 83	URS CORPORATION	SALT LAKE	SALT LA[illegible]	9	
SEPT 83	ISOMEDIX, INC.	SALT LAKE	SALT LAKE	59	
SEPT 83	RIVENDELL	WEST VALLEY CITY	SALT LAKE	199	
OCT 83	UNISTRUT			40	
OCT 83	RADIX CORP.			59	
OCT 83	NATIONAL SEMICONDUCTOR	WEST JORDAN	SALT LAKE	1,225	
OCT 83	STOUFFER FOODS	SPRINGVILLE	UTAH	1,200-1,700	
OCT 83	LITTON INDUSTRIES	SALT LAKE	SALT LAKE	572	
NOV 83	SELECT TELEPHONE SYSTEMS	SALT LAKE	SALT LAKE	2,200	
NOV 83	G. H. INDUSTRIES			258	
NOV 83	FIRST CONTINENTAL LIFE			104	
NOV 83	AMERICAN EXPRESS			481	

Representative LUNGREN. Thank you very much, Governor Matheson.

Governor Thornburgh.

STATEMENT OF HON. DICK THORNBURGH, GOVERNOR, STATE OF PENNSYLVANIA

Governor THORNBURGH. Congressman Lungren, I greatly appreciate the opportunity to testify before you today on a subject of great importance to the Commonwealth of Pennsylvania. I'm very pleased to appear on the same panel with the distinguished Governor of Utah, Scott Matheson, who, as you know, is a past chairman of the National Governors Association.

There's a unique tie between Governor Matheson and myself in that he and I, in our prior incarnations, were corporate lawyers and have some insight into some of the frustrations the private sector has in dealing with government in all levels.

I'm pleased to share with you my views on State strategies to improve the climate for innovation and economic growth. My prepared statement, which has been submitted for the record, outlines the strategic planning process that has been utilized in the Commonwealth of Pennsylvania and sets forth the elements of our overall economic development strategy which is designed to meet the challenge of the somewhat wrenching transition of our economy from its traditional heavy industrial base to the industries of tomorrow.

In order to increase the time to respond to your questions, I will focus during my remarks on only our advanced technology efforts, relating them to the overall strategy outlined in my prepared statement.

In February 1982 I proposed to the Pennsylvania General Assembly a working partnership between academic, governmental, and private sector resources to help stimulate the development and application of advanced technologies within our State. I hoped that this partnership would spark an aggressive drive to diversify our State's economy, spur entrepreneurship, and assist our educational and training institutions in preparing youth and adults for the jobs of tomorrow.

I called this program the Ben Franklin Partnership, after that famous Pennsylvanian who excelled as a scientist, inventor, educator, businessman, and, yes, statesman. Four Ben Franklin Partnership Advanced Technology Centers have been established at major universities in our State since that time. Each represents a consortium of business, labor, research universities, and other higher education institutions and economic development groups.

Our centers are headquartered at Lehigh University, Pennsylvania State University—our land grant institution—Philadelphia's University City Science Center—itself a consortium of a number of educational and private sector groups—and jointly at the University of Pittsburgh and Carnegie Mellon University in my hometown of Pittsburgh.

These are not programs simply to subsidize more academic research. They are designed to move advanced technology initiatives out of the laboratory and on to the shop floor to create new jobs and business opportunities for Pennsylvania.

Nor are these jobs just for those with advanced scientific or engineering skills. Somehow the myth has grown up in some quarters that every Mr. Goodwrench would have to become Dr. Advanced Thinker to participate in Advanced Technology job growth. The record clearly indicates that the majority of these jobs will be blue collar in nature and require at most a high school diploma and up to 2 years of technical training.

Our centers began operation in March 1983 with $1 million in initial financing from the State, matched by more than $3 million from the private sector, colleges and universities, foundations, and other sources. During this physical year we will exceed the $100 million level in public and private financing committed to what is now the largest annual State technological innovation program in the Nation. In addition, some $12 million in venture capital has been attracted to Ben Franklin supported programs. We also have in operation the largest number of small business incubators of any State in the Nation.

The key to the success of this endeavor is the fact that the private sector is its driving force. Private sector representatives serve on the policy and advisory boards of each center volunteering services, facility, and equipment, providing a significant amount of the matching funds and helping to set the priorities for specific research and development work.

Our Ben Franklin Partnership builds on one of our State's great assets, our major research facilities We have 4 of the top 50 graduate research universities in the Nation in Pennsylvania. In addition, 80 of the State's 135 colleges and universities and more than than 1,700 businesses, representing both small and large firms, are involved in more than 300 projects sponsored by the partnership.

In my prepared statement I have set forth specific examples of the type of projects that are being carried out and I earnestly invite the committee and its staff to take advantage of our offer to visit any of the Partnership Advanced Technology Centers for further details.

The Federal Government has undertaken, and must continue to undertake, a major role in funding basic research because benefits of this research do not accrue simply to one State or region and it's only the Federal Government which has the variety of revenue sources available to provide significant financial support for basic research. However, as you've heard from Governor Matheson and others, I am sure, States can and must plan and play an important supporting role as catalysts in technology transfer, in applied research and development, encouraging partnerships between business and higher education, and in making better use of our educational assets.

Among the most critical factors attracting technology oriented firms are a skilled work force, a high quality of life, positive community attitudes, and access to higher education and related research facilities. States which make investments in their communities, in their educational systems, in support for the arts, culture, library, and recreational facilities, in clean air and water, in anticrime measures, and in creating overall a favorable environment for new entrepreneurs will be those which attract the new and exciting prospects for the economies of tomorrow. We have made these our priorities in Pennsylvania. A war between the States which concentrates on these factors rather than random smokestack chasing will benefit all of us.

A final important part of our overall economic development program is concentrated on increasing available capital. In June of this year our General Assembly approved my proposal for a 10-percent reduction in our corporate net income tax which will free an anticipated $180 million over the next 3 years for new investments.

Our Pennsylvania Industrial Development Authority, or PIDA, has served since the mid-1950's as a role model for other States in the allocation of low interest loans for business expansions. In 1980 this program was altered through legislation to provide additional incentives for firms with fewer than 50 employees.

Since then the number of small businesses receiving PEDA loans has more than tripled and today nearly half of all these loans go to small businesses. In addition nearly $50 million of PEDA funding has gone to advanced technology firms which currently are targeted for 25 percent of its resources.

Another source of capital was made available by channeling State-controlled Federal Appalachian Regional Commission funds to a newly created Pennsylvania Capital Loan Fund. This year an additional $15 million in State funds were earmarked to supplement ARC dollars over the next 3 years.

Recently I also signed legislation permitting the use of up to 1 percent of our State public school employee and public employee retirement funds to provide up to an additional $100 million in venture capital for the birth and expansion of small entrepreneurial firms.

Finally, Pennsylvania voters this spring approved by a 2 to 1 margin a $190 million bond issue to fund a variety of other new initiatives, such as providing loan assistance to employees who wish to buy out firms that otherwise might close or move elsewhere, increasing aide to our Pennsylvania Minority Business Development Authority, providing loans and grants for business infrastructure improvements associated with major industrial expansion and supplementing existing small business incubator and educational programs.

Pennsylvania's economic development strategy has been carefully designed to ensure that our State capitalizes on the potential of advanced technology growth so as to become a full participant in the Nation's economic recovery. The National Governors Association Task Force on Technological Innovation, of which I serve as vice chairman, found that nearly all States are undertaking similar initiatives to address their particular economic problems.

Technological innovation, as Governor Matheson has reminded us, has been found to be a critical element in nearly every State's economic development strategy. These strategies rely on the strong American traditions of entrepreneurship and innovation. For me there can be no better historic example of this spirit than our own Ben Franklin. As one French admirer said of Franklin, he snatched the lightning from the heavens, literally and figuratively.

We should strive to be as bold in our strategies at both the Federal and State levels in developing sound economic programs.

Thank you very much, Mr. Chairman, for the opportunity to be with you today.

[The prepared statement of Governor Thornburgh follows:]

PREPARED STATEMENT OF HON. DICK THORNBURGH

STATE STRATEGIES TO IMPROVE THE CLIMATE FOR INNOVATION AND ECONOMIC GROWTH

Ladies and Gentlemen, Members of the Joint Committee:

I appreciate the opportunity to testify before you today on a topic of great importance to the Commonwealth of Pennsylvania. I am pleased to share with you my views on "state strategies to improve the climate for innovation and economic growth."

Since I became governor of Pennsylvania in January 1979, economic development has been a top priority of my administration.

Even before the recent recession, we recognized that Pennsylvania would be facing major challenges in the years ahead--particularly as we began the decade of the 1980s--in managing the transition of our economy from its reliance on traditional heavy industries to the industries of tomorrow. Soon after my election, I asked our State Planning Board to initiate a new strategic planning effort for the Commonwealth to cope with these challenges.

We called this effort "Choices for Pennsylvanians" in the belief that the choices affecting our future economic development could best be made most effectively, not by government alone, but by all Pennsylvanians: by business, labor, civic leadership, educators and private citizens--by the private sector in conjunction with, and not at the direction of, state and local governments. Our purpose was to identify the role which government could play as a catalyst, not a dictator, in helping to fashion the economic future of our Commonwealth.

More than 185,000 Pennsylvanians participated in the "Choices" process through regional meetings, public opinion surveys and a statewide public television documentary. The final "Choices" report reflected the deliberations of a State Planning Board composed of cabinet members, legislators and private citizens, including the presidents of both the Pennsylvania Manufacturers' Association and the Pennsylvania AFL-CIO.

We believe our exercise in strategic planning has provided an agenda for action which will enable us to compete effectively at home and abroad during the balance of this century.

Two important premises underly our strategy. First, we naturally recognize, that, to a great extent, our state economy is dependent upon national and international economic conditions and forces beyond our direct control. Second, in the final analysis, it is private-sector decisions--decisions to invest, expand or relocate--which will dictate whether our efforts to stimulate economic growth will succeed or fail.

Our strategy, therefore, is designed to enable state government to capitalize on positive changes in national and international economic trends. At the same time, we have not succumbed to the false notion that government itself can create meaningful and permanent jobs. Ratner we have recognized that solving the problems of an economy in transition has less to do with throwing tax dollars at these problems than with implementing policies and programs to create an environment conducive to favorable private-sector decisions.

The first priority identified by our economic development strategy was to assist existing Pennsylvania firms to stay in business and expand. Our second priority was to encourage the start-up of new firms, particularly small businesses on the cutting edge of technological innovation where most new job growth will develop. And our third priority was to selectively recruit new plants and investment, especially from those industries which would help diversify our economic base and offer long-term growth potential.

This strategy is one which we believe makes sense for large industrial states like Pennsylvania, a strategy designed to keep our businesses in business, while at the same time attracting and developing new enterprises to provide new jobs for our working men and women.

We have pursued a non-traditional set of approaches in implementing our strategy. Each element involves specific policies, programs and actions that relate to the three parts of our overall strategy. These six basic elements are:

- Creation and preservation of a positive business climate
- Enhancement of our traditional industrial base
- Capitalization on advanced-technology opportunities
- Development of job-training and retraining programs
- Investment in infrastructure improvements

* Encouragement of excellence in our quality of life.

So that I may have time to respond to your questions, I will focus during my remarks on only our advanced-technology efforts and relate them to the overall strategy I have outlined.

In February 1982, I proposed to the Pennsylvania General Assembly a working partnership between academic, governmental and private-sector resources to help stimulate the development and application of advanced technologies in our state. I hoped that this partnership would spark an aggressive drive to diversify our state's economy, spur entrepreneurship and assist our educational and training institutions in preparing youth and adults for the jobs of tomorrow.

I called this program the "Ben Franklin Partnership," after that famous Pennsylvanian who excelled as a scientist, inventor, educator, businessman and--yes--statesman.

Four Ben Franklin Partnership advanced-technology centers have been established at major universities in our state since that time. Each represents a consortium of business, labor, research universities and other higher-education institutions and economic development groups. Our centers are headquartered at Lehigh University, Pennsylvania State University, Philadelphia's University City Science Center, and jointly at the University of Pittsburgh and Carnegie-Mellon University.

These are not programs simply to subsidize more academic research. They are designed to move advanced-technology initiatives out of the laboratory and onto the shop floor to create new jobs and business opportunities for Pennsylvanians.

Nor are these jobs just for those with advanced scientific or engineering skills. Somehow the myth has grown in some quarters that every Mr. Goodwrench would have to become Dr. Advanced Thinker to participate in advanced technology job growth. The record clearly indicates that the majority of these jobs will be blue-collar in nature and require, at most, a high school diploma and up to two years of technical training.

The centers began operation in March 1983 with $1 million in initial financing from the state, matched by more than $3 million from the private sector, colleges and universities, foundations and other sources.

During this fiscal year, we will exceed the $100 million level in public and private financing committed to what is now the largest annual state technological innovation program in the nation. In addition, some $12 million in venture capital had been attracted to Ben Franklin-supported programs. We also have in operation the largest number of small business incubators of any state in the nation.

The key to the success of this endeavor is the fact that the private sector is its driving force: Private-sector representatives serve on the policy and advisory boards of each center; volunteering services, facilities and equipment; providing a significant amount of the matching funds; and helping to set the priorities for specific research and development work.

Our Ben Franklin Partnership builds on one of Pennsylvania's great assets--our research facilities. In fact, we have four of the top 50 graduate research universities in the nation. In total, 80 of the state's 135 colleges and universities and more than 1,700 businesses, representing both small and large firms, are involved in more than 300 projects sponsored by the partnership. For example:

* Carnegie Mellon University and United States Steel are developing an automatic control, computer-operated system for an integrated hot rolling mill to be utilized at four Pennsylvania mill sites. A total of 310 jobs should be retained through this process.
* The University of Pennsylvania and a private research firm developed tests and cures for bovine leukemia, a frequently malignant disease of cattle and one which affects dairy cattle in Pennsylvania.
* American Robot Corporation and Carnegie Mellon University are developing direct digital drive robots to meet the express needs of large users, such as automobile companies, machine tool builders or electronic companies. More than 600 jobs are anticipated to be generated through this venture.
* The University of Scranton and a local glass firm are using CAD/CAM to develop technologies to optimize glass

cutting yields. The technology developed should also be applicable to the cloth cutting and needle trade industry.

- Edinboro State University is providing a training program for minorities in hospital medical equipment repair.

Ninety percent of the nation's knowledge in the physical, biological and other basic sciences has been gained since World War II. The application of this knowledge is resulting in emerging technologies which are reshaping our traditional industrial base and all occupations.

Technology can create jobs in high-growth areas, such as electronics, computers and telecommunications. In addition, technology can affect the service sector of our economy, which is becoming increasingly more information-based and knowledge-based. Post-high school technical training, in particular, will be critically important in this technological age.

The federal government has undertaken, and must continue to undertake, the major role in funding basic research because benefits of this research do not accrue simply to one state or region, and it is only the federal government which has the variety of revenue sources necessary to provide significant financial support. However, states can and must play an important supporting role as catalysts in technology transfer, in applied research and development, in encouraging partnerships between business and higher education, and in making better use of our educational assets.

Among the most critical factors attracting technology-oriented firms are a skilled work force, a high quality of life, positive community attitudes and access to higher education and related research facilities. States which make investments in their communities; in their educational systems; in support for the arts, culture, libraries, and recreational facilities; in clean air and water; in anti-crime measures; and in creating a favorable environment for new entrepreneurs will be those which attract the new and exciting prospects for the economies of tomorrow. We have made these our priorities in Pennsylvania.

"A war between the states" which concentrates on these factors and not random "smokestack chasing" will benefit us all.

At the same time, we must continue to provide support mechanisms for advanced-technology growth. Pennsylvania was one of the first states to develop and implement a set of specific advanced-technology policies.

We established the Governor's New Product Award Program and the Governor's School for the Sciences, which provides an intensive summer program of college-level instruction for outstanding sophomore and junior high school students. Our Small Business Research Seed Grant Program provides research and development funds directly to small firms active in technological innovation.

We have initiated a threefold increase in high school science and mathematics graduation requirements. We support the nation's premier technology transfer organization in the Pennsylvania Technical Assistance Program (PENNTAP). We also have earmarked federal and state funds for technology training, including computer literacy in the schools and the upgrading of mathematics and science skills of our public school teachers.

In addition, an important part of our overall economic development program is concentrated on increasing available capital. In June, the General Assembly approved my proposed 10 percent reduction in our corporate net income tax, which will free an anticipated $180 million over the next three years for new investment.

Our Pennsylvania Industrial Development Authority (PIDA) has served since the 1950s as a role model for other states in the allocation of low-interest loans for business expansions. In 1980, this program was altered through legislation to provide additional incentives for firms with fewer than 50 employees.

Since then, the number of small businesses receiving PIDA loans has more than tripled, and today nearly half of all these loans go to small businesses. In addition, nearly $50 million of PIDA funding has gone to advanced-technology firms, which currently are targeted for 25 percent of its resources.

Another source of capital was made available by chanelling state-controlled federal Appalachian Regional Commission (ARC) funds to a newly created Pennsylvania Capital Loan Fund. This year an additional $15 million in state funds was earmarked to supplement ARC dollars over the next three years.

Recently I also signed legislation permitting the use of up to 1 percent of our state public school employees retirement funds to provide up to an additional $100 million in venture capital for the birth and expansion of small entrepreneurial firms.

Finally, Pennsylvania voters this spring approved by a 2-1 margin a $190 million bond issue to fund a variety of other new initiatives, such as providing loan assistance to employees who wish to buy out firms that otherwise would close or move elsewhere, increasing aid to our Pennsylvania Minority Business Development Authority, providing loans and grants for business infrastructure improvements associated with major industrial expansions, and supplementing existing small business incubator and educational programs.

Pennsylvania's economic development strategy has been carefully designed to insure that our state capitalizes on the potential of advanced-technology growth so as to become a full participant in America's economic recovery.

The National Governors' Association Task Force on Technological Innovation, of which I serve as vice chairman, found that nearly all states are undertaking similar initiatives to address their particular economic problems. Technological innovation has been found to be a critical element in nearly all state economic development strategies.

These strategies rely on the strong American traditions of entrepreneurship and innovation. For me there can be no better historic example of this spirit than our own Ben Franklin. As one French admirer said of Franklin: "He snatched the lightning from the heavens." We should strive to be as bold in our strategies for economic development.

Thank you.

Representative **LUNGREN**. Thank you very much, Governor, and to both of you. I want to thank you for your testimony, for the time that you spent in coming down here, and presenting your testimony.

You both alluded to it somewhat but I'd like maybe specific comments on it. To what extent do you believe State and local governments are getting away from the beggar-thy-neighbor job pirating strategies that many of our States engaged in in the past, and are now concentrating more on the strategies you spoke of here today, that is, as I understand it, developing strengths in your own States, assisting the startup of new firms and the expansion of already existing firms?

Governor **THORNBURGH**. I think the overall concensus of State governments today is to get away from smokestack chasing. I think even a look at the statistics would indicate that very few major opportunities for industrial expansion arise from that particular strategy. My recollection is that statistics show that less than 5 percent of the new jobs created nationwide result from shifts in business location.

In our State we have enunciated a specific strategy which has three components. The first priority is to assist existing Pennsylvania firms to stay in business and to expand. The second is to encourage the start up of new firms, as I mentioned in my testimony, particularly small businesses on the cutting edge of the technological innovation. And our third priority is to selectively recruit new plants and investment, especially from those industries that might help diversify our economic base and offer long-term growth potential. With two emphases: One on attracting more foreign investment, that is, investment from abroad, and, second, effectively competing for some of the advanced technology opportunities that are going to be there without smoke stack chasing.

The best example of that, Congressman Lungren, I think is a firm from the Silicon Valley, Z-Beck [phonetic], from Ed Chiles district that was looking for a locale on the east coast to establish their operation. Having been attracted to look at Pennsylvania through our Advanced Technology Center at Lehigh at Bethlehem, they established their locale and hold out the promise of about a thousand new jobs there that will give them a foothold in the east coast markets.

It's a kind of a leap from the Silicon Valley to the Lehigh Valley, which we think is indicative of the kind of opportunities that are available in a State like ours.

Representative **Lungren**. Governor Matheson.

Governor **Matheson**. I think that traditionally it would be fair to say that there was a time when we would go out and capture bodily and bring any job into the State, regardless of what the nature of the job was, simply because the need to have that particular piece of business was so great. But you learn very quickly in the world of reality that you have end up targeting your State policy on how you survive in the economic broadening of your State's base.

And so, while we traditionally sought employers in the traditional way, the targeting concept of what we have uniquely to offer to those we wish to join us has become the public policy in our State. One of the things that we have discovered, interestingly enough, is that while we all love to go out and court major new business—but they don't come into your State very often.

The way you really make this work is you go out and you develop an atmosphere that attracts little pieces of businesses that come over a period of time and over 80 percent of all of the jobs in our States come from very small businesses.

We made an interesting discovery. If you can find ways to help that small businessman, give him a small business revitalization loan, if you can give him some incentive at the State level through legislation, if you can give him some inducement, if you can provide him with trained people in his business when he needs them, then your base suddenly begins to broaden. So we have attempted to develop our resources directed in a dramatic way toward that small businessman who produces over 80 percent of those jobs and we have attempted to do that by encouraging business that is already there to expand and modernize, but we are still anxious to bring new business into the State.

The idea of going out and recruiting another Kennecott or a new Geneva Steel, those things simply don't happen in the real world today and those are industries that are being squeezed down. So, the strategy now is to target and to try and go into the areas where you can find measurable successes.

Just one example. We have one of the major Federal installations in our State, Hill Air Force Base, and they do about $40 million of business a year with contracts with small business. Much to my dismay, when I looked at the list, most of that business was going to small business outside of my State. And the reason we discovered was because the people in the State didn't know how to effectively prepare the bids and compete for the business. So we decided that we would train our small businessman to go out and do the things that he had not traditionally done and that's the kind of relationship that we want the small businessman to have in the State and now we're starting to pull off some of that business.

And that, basically, I think is the atmosphere that we've used.

Representative LUNGREN. Obviously, there's a general agreement that the old practice of smokestack chasing doesn't make sense in today's environment. But, let me just ask you about the episode we had with MCC, that joint venture of a number of high tech firms to establish a research and development center. Is that smoke stack chasing with a new twist? Is that high-tech chasing?

Governor THORNBURGH. Chip chasing.

Representative LUNGREN. Chip chasing? Is that unique or is that a suggestion that perhaps we're going to fall into the old trap again of trying to take something from other States as best we can? I mean, obviously, the company wants to come in. You're going to do everything you can to bring them in, but that's different than a strategy of specifically going out and trying to pick off the fruit from trees of other States.

Governor THORNBURGH. Yes, I think both Scott Matheson and I would agree. We wouldn't turn anybody away and the MCC thing I think is somewhat illustrative, but unique. We were among those who talked to that organization at the time that they were kind of up for grabs, but obviously the Texas commitment was so heavy in terms of financial commitment that we didn't feel we could get beyond the first or second round.

And I think we're a little bit wary of those propositions. In the mid-1960's in a great deal of—or mid-1970's in a great deal of flourish we attracted a major foreign investment, Volkswagen, in Pennsylvania. Held out the promise of some 5,000-7,000 jobs and made substantial commitments in terms of tax abatement, financial aide from the State, and attracted a good deal of attention.

Today that facility is struggling and the job projections have not been realized, and while we have extended every bit of assistance we can in terms of job training and modernization, I think there is the hint of a lesson there about putting all of your eggs in one basket.

But we have tried to learn, as Governor Matheson indicates the policy is in Utah, of being more diversified, focusing more on small business, adopting specific strategies that are designed to help the entrepreneur. That I think is the keystone of what we are looking at, of giving a menu to the prospective entrepreneurial investor and actor that enables him to take advantage of what we can do.

Let me just mention a couple of examples if I might, Congressman Lungren. We mentioned, both of us, I think, in passing, the small business incubator concept. This provides a physical facility where a number of small businesses—in fact, in many cases one person—can headquarter himself or herself and use joint and common facilities for stenographic services, for photocopying, for computer terminals, and the like, when they are getting started, when they don't have a million dollars in venture capital socked away.

Second, programs of technical assistance. How do they keep their books? What kind of contract form should they have? The kind of things that are cranked out for major multinational corporations by giant legal and accounting staffs simply aren't available to the one-man, two-man, what have you operation.

So those kinds of things that can be furnished, the technical bases.

The other is what Scott mentioned, about regulatory review. We have a small business action center, one phone number where a small business person can call and get help in working through the maze of the bureaucracy without being fobbed off one after another to 12 or 15 different agencies where forms, permits, regulations, and the like have to be dealt with. We have had some 30,000 phone calls to that number, and I think about 29,995 satisfied customers from that service.

Representative LUNGREN. Probably only get the letters from the five that were not satisfied.

Governor THORNBURGH. Well, that is right. I hear from them.

Finally, another thing that I couldn't agree more with Governor Matheson on, and that is this business of procurement. Small businesses that ought to be encouraged and helped and aided and informed about the Government procurement process so that they can participate, No. 1, for their own good but, No. 2, for the good of Government because more competition is going to produce lower prices and lower cost to the taxpayer if some of these smaller, more efficient, cost-efficient operations are participating in the procurement process.

Those kinds of specific strategies, it seems to me, are targeted directly at the small business entrepreneur about which you have expressed your principal concern.

Representative LUNGREN. Let me ask this question to both of you, and that is, you both mentioned the centrality of the university and college community toward not only basic research, for which you both suggested the Federal Government has primary responsibility, but in terms of the transfer of that basic research into real use, help to businesses and so forth. There is no doubt, it seems to me, that this is something that is necessary, but in many ways it is a nontraditional role for the universities and colleges.

We had hearings about 1 year ago on a slightly different subject, but somewhat related, on the question of the training and retraining of the American work force. We had testimony from a number of different States as to how they had some resistance on the part of the college community toward allowing the private sector to come in and give them not only just some advice but some real direction as to where they should be training people because it would be an insult to train someone for a job that doesn't exist.

Have you experienced any reluctance or any problems on the part of the universities in this nontraditional role of technology transfer, if I might just use a very general term, as opposed to basic research?

Governor Matheson.

Governor MATHESON. We have had several years of productive experience with our institutions of higher learning. However, the main support comes from that portion of the university family that is in the technical field. Those who are experienced in doing the job and who have been in the basic research are usually quite sophisticated about sharing and developing processes with the State and the private community. The administrative people sometimes, the managers are sometimes a little bit difficult to deal with and like to keep jurisdictional lines fairly separated.

But for example, I went to one institution of higher learning and had lunch in the research park and the president of the institution had never been in the research park. And that kind of example kind of shook me up a little. That has all changed, and we suddenly realized that all of the pieces of action at the institutional level on the campuses and in the research park have to fit into all of the things that are going on in the Government and in the private sector and all of us have to work at this very closely together because we can't waste anything any more. And so the public/private partnership concept, which I absolutely think is the key to how you fit this all together, is beginning to make more sense.

May I just point out last, you mentioned the role of the Federal Government in basic research. I am absolutely convinced that if we don't maintain our commitment to basic research—and I don't meant the Federal Government ought to pay all of that bill, but that is one place the Federal Government is very, very helpful and valuable in this equation we are talking about today because if you don't have ideas this whole thing fails. You got to convert ideas into whatever we do, and so I encourage you when you are looking at what recommendations you might wish to extract from your hearings, that basic research commitment from the Federal Government I think is absolutely critical.

Representative LUNGREN. Governor Thornburgh, please comment about the question of the difficulty, if any, of the university and college community in filling this role.

Governor THORNBURGH. Well, there is an awkwardness on occasion when pure academe comes up against the realities of the free enterprise system, but there is a tried and true technique that we have used in funding our Ben Franklin partnership centers; that is, funding them on a competitive basis, and the basis for judging how we divvy up the State share of the appropriation is not the basis of how much basic research or laboratory work that can be done but what is being done to transfer the technology into the marketplace and create jobs, which is the prime indicator that we utilize. And thus far that process has worked very well.

I think at the outset there was, frankly, on the part of some actual or potential participants in this program a view that this was just one more subsidy for further academic research that could be used as the university or college chose to do so. But I think that has been dispelled, and in fact there is a very positive response from the universities and a recognition that this interaction with the real world of entrepreneurial growth is a positive thing from their point of view.

On job training I think there is a real untapped potential. I have submitted to the committee this morning a report issued just yesterday in our customized job training program in Pennsylvania. This, it seems to me, is one of the most exciting things for an economy whose base is in such a transition as we are.

We have communities in our State where generations have worked in the c[illegible]ines, the steel mills, heavy industrial plants that were long [illegible]allmark of Pennsylvania's industrial base, and those jobs aren't there any more. Because of increased efficiency, technology, and frankly a good deal of unfair foreign competition, those job pools have shrunk, and the challenge of training and retraining those individuals who grew used to relying on the industry is enormous.

The traditional job training technique used in our State, and I suspect in many others, was to take a pool of able-bodied men and women, train so many of them as carpenters, painters, electricians, and welders and when they were through tell them to go get a job. Through the customized job training process we have gone to employers and said:

> What do you need, and if we train them will you guarantee them a job at the end of the process, or if you have a current work force which needs to be upgraded in skills and talent to operate in the new technology that you have in your plant, if we pay the tab will you commit to stay here and continue to provide that kind of employment?

Over the last 2 years, as exemplified in this report, we have seen some 4,500 Pennsylvanians at a very low cost provided with that kind of job security and job enhancement, simply on the basis of saying we are not going to train you for jobs that may not be there, but we are going to absolutely ensure that those jobs are going to be forthcoming.

Now, that process has in turn involved a lot of our smaller community colleges and other educational institutions because the plant that I was in Pittsburgh yesterday, at Union Switch and Signal, which has been one of the major participants in this operation, they found simply that they couldn't do all the training with their in-plant personnel, and that has brought them into contact with the Allegheny County Community College in Pittsburgh, which has provided a lot of the training personnel, and a spinoff there of their further insights into the techniques that can be utilized, in this case computer-assisted design, computer-assisted manufacturing programs, and you are creating a whole new community out there which is supportive of the transition that we have to undertake.

Representative **Lungren**. The other day we had hearings as part of this series on an area that I really wasn't that conversant in, that of Federal labs, and although they can't be the primary source of technology transfer or technological innovation they are a resource that we ought not to ignore, and I think that many of us in Government on the Federal level have not understood their importance. The individuals who testified, representing the Federal labs, indicated that a catalyst was needed to bring together all the players—private companies, universities, the Federal Government and the Federal labs—and they seemed to suggest that the States would be the natural level or entity to play that role.

I might ask both of you what your experience has been with the Federal lab system and what you think the States might be able to do to encourage the technology transfer from these laboratories, recognizing they won't provide a majority of it but that it is a resource that we ought not to forget about.

Governor **Matheson**. I think the idea of folding the Federal lab overall technology into the operations at the State level is a productive thought. We do not have a great deal of association with the Federal labs, but frankly they are very helpful to us with respect to grant requests. They make their equipment accessible to us at our institutions of higher learning basically on request. We have an excellent working relationship with them. Where there is research that is compatible we often do that jointly.

One of the interesting ways that we have been able to utilize them is to send graduate students from our institutions of higher learning into the labs on a transfer basis where they have had productive learning experiences. I don't think we have really developed that relationship in the sense that you are describing, but I certainly think that we have the basis upon which a productive relationship of that kind could be developed.

Representative LUNGREN. Governor Thornburgh.

Governor THORNBURGH. We have eight Federal labs in Pennsylvania and through the Federal Laboratory Consortium are able to develop a fair idea of what use can be made of those facilities, and in many cases they have proved to be extremely valuable.

There are two things that I think perhaps are worth mentioning in this regard. Earlier this year I testified before the Senate Judiciary Subcommittee on Patents, Copyrights, and Trademarks in support of Senator Dole's bill S. 2171, which would widen the potential for use of patents developed with Government funds, and in connection with that the U.S. Commerce Department under this pending legislation would be given overall responsibility for creating a climate favorable to the commercialization of the results of federally funded research.

How that relates to the labs, I think, is that while we are aware of and in contact with the eight labs in Pennsylvania we have very little idea of what the other labs outside of our region do, and if there was a centralized clearinghouse and a loosening of the ability of entrepreneurial efforts to capitalize on some of this Federal research I think you would see a veritable explosion in the use of the very important research and development work that is done by these Federal laboratories.

Representative LUNGREN. One of the intriguing things we found out in our discussion was that there is a center of information that is supposed to then make available this information to businesses, State governments, and so forth. They indicated to us that the No. 1 user of that information at the present time is a small, little, tiny company you probably never heard of called Mitsubishi.

There seems to be a lack of information that that information is available, and I think those of us in Congress are probably as guilty as anybody and one of—I guess it is called the National Technical Information Service—one of the things I want to do after these hearings hopefully is to make Members of Congress aware and make State authorities aware of this fact because if Japan is using it and then actually applying it in terms of their industry——

Governor THORNBURGH. They probably don't feel constrained——

Representative LUNGREN [continuing]. Then obviously it is worthwhile and we are not using it.

Governor THORNBURGH. I don't think they feel particularly constrained by our patent laws in that regard either. That may have something to do with it.

Representative **Lungren**. But this is information that is available, readily available, publicly. But I think you make a good point that we ought to do a better job of making sure that not only you know what is going on in the eight national labs that are in your State but also others.

I know that your time is short, Governor Thornburgh, and I know, Governor Matheson, you have to leave as well. Let me just ask you one quick question, and if we don't have time for you to go into it maybe you could submit an answer to it.

Recently the voters of Rhode Island soundly defeated a proposal of industrial policy for their State. I think the vote was something like 80 to 20, which is about as strong a commitment you are ever going to get from the voters in any direction. And some had suggested that that proposal that was defeated was the blueprint for economic development in that State.

I wonder if you might be able to contrast your own experience with that of the Rhode Island case, suggesting perhaps where that went wrong and where your State's approach towards that development is different from that.

Governor Thornburgh.

Governor **Thornburgh**. Well, far be it from me to expertise on the Rhode Island experience. I have got enough problems——

Representative **Lungren**. I know that is kind of a dicey thing to ask you to do, but it certainly hit with a thunderbolt here around those who were talking about a national industrial policy.

Governor **Thornburgh**. Yes; I can certainly tell you this, that in Pennsylvania our voters approved by a 2-to-1 margin a $190 million bond issue, which was just short of the amount that was talked about in Rhode Island, that had been developed on a consensus basis with bipartisan support, with private sector input, in a very careful and deliberate way that we felt built upon and supplemented our ongoing efforts that I have described here today rather than attempted to overlay what we thought was a careful and methodical program with something called an industrial policy.

I think you can gather, Congressman Lungren, from my remarks and I suspect Scott's today that being in the governmental business ourselves we are somewhat wary of delegating to elected or appointed officials the direction of our economy. I cannot reiterate strongly enough how much of our success in adapting to the need for change in Pennsylvania has depended upon the enthusiasm of the private sector. I mentioned that we have now committed over $100 million in our Ben Franklin program. That was supposed to be done on a 1-to-1 basis, one public dollar, one private dollar. In point of fact, private response has been about $3 private for every $1 public, and that is a fair measure of the degree of enthusiasm that has been expressed for the entire project.

So I think that government's role as a catalyst rather than a dictator of economic trends is far more productive, and my guess would be that at least in perception part of the problem in Rhode Island might have been that difference.

Representative **Lungren**. Governor Matheson.

Governor **Matheson**. We went through an interesting exercise called The Agenda for the 1980's and we tried to sit down and disect what the industrial future of our State ought to be and input came in on a broad basis and we received a whole series of recommendations for bonding and for other things to do.

The interesting thing that I now in retrospect see is the level of success of the recommendations of the agenda for the 1980's is directly proportional to how much homework we put into getting that implemented. If you get the business community to support a bond issue or whatever we think ought to be a part of that policy, we've been able to, on a case-by-case basis, market those ideas.

Occasionally, where you want to do something of that sort and you don't go out and do your homework, you can lose. That happens occasionally as well, but, for example, bonding is a major part of investment in your public infrastructure which, of course, is a part of your economic base and I've gone before my legislature nine times and they've bonded nine times since I've been Governor, which is three times as much as all of the bonding in the State's history.

So, I think that we're maturing in our State, in the sense we're willing to go out and gamble a little more in those specific areas and I applaud that. But, I have something going in my State that I'm sure that Dick has as well.

We have a tradition of investing in our own future and building and working. It's something that everybody takes for granted. So, if I can harness those attributes into an industrial concept it has a good chance of success simply because of the background of the State.

Representative **LUNGREN**. Well, I want to thank both of you for appearing here. I've got a whole host of questions I could continue to ask on this issue. It's obviously a very interesting one and one that hopefully the Congress will pursue.

As I said, sometimes we forget the human element here. How do you encourage the human element? How do you encourage entrepreneurship as opposed to just viewing things? How do you take somebody or some company from some other State and take care of your problem short term?

I know both of you have to leave. I want to again thank you, and, Governor Thornburgh and Governor Matheson, enjoy the Olympics and if you happen to see volleyball, remember it's in my district. [Laughter.]

Governor **THORNBURGH**. Thank you, Congressman Lungren.

Governor **MATHESON**. Thank you, Congressman Lungren.

Representative **LUNGREN**. OK. At this time I'd ask Mr. Donald Beilman, the president of Microelectronics Center of North Carolina, and Mr. Peter Brennan, a partner of Brennan & Garson, to come forward and appear on the same panel.

To both of you, I would like to extend greetings and thank you for the time that you spent in preparing your testimony, as well as the time to be spent here. We could go on and on this for hours and days. Unfortunately, we have the press of time of about an hour and, so, I would ask that your prepared statements will appear in the record as they are and ask you to proceed as you wish.

And perhaps if you could try and limit your opening remarks to between 10 and 15 minutes, we could then get into questions and answers. Hopefully, questions would be prompted by your testimony this morning. So, Mr. Beilman, if you'd like to begin.

STATEMENT OF DONALD S. BEILMAN, PRESIDENT, MICROELECTRONICS CENTER OF NORTH CAROLINA

Mr. **Beilman**. Thank you, Congressman Lungren, for this opportunity to express my views on North Carolina's strategies for improving the economic climate for innovation and growth. We hope our experiences and approaches will be of value to the committee and others interested in this strategic area.

As I prepared this statement I've tried to incorporate my views currently as the president of the Microelectronics Center of North Carolina, as well as from my prior 30-year career experience as a business executive in high technology industry.

The United States has maintained it's leadership in technology by providing a permissive environment in which to foster new ideas and innovations. I think the challenge before us now is to develop a hightened permissive environment to meet the more intensive international competition, and this requires business, education and Government to work together in new and creative ways.

My comments today will focus on how States in general and North Carolina in particular become full partners in promoting and supporting nondefense technology innovation for maintaining world economic leadership. I say nondefense, recognizing that defense outlays for R&D are very substantial, 65 to 75 percent of total Federal R&D funds.

The predominant motivation for State action is to develop conditions within each State which provide more and better jobs for people. The result is that State governments are assuming more responsibility for technological innovation.

In 1982, North Carolina Gov. Jim Hunt stated that:

> In matters other than defense and space, the center of gravity for technological innovation must shift from the Federal Government to State governments.

This process is well underway in North Carolina and it has continued to be the policy of our State.

The evolution of the State of North Carolina to the position of leadership in technological innovation is the result of a consciously structured, coherent, statewide strategy. I use the word "strategy" as contrasted to industrial development policy because I believe States can have some influence on the direction of their economic development from an industrial point of view, rather than just individual acts to stimulate business activities in the State.

This approach is in contrast to the old fragmented efforts by Department of Commerce shotgunning for any and every segment of industry. North Carolina's new technology initiative began nearly 30 years ago with the establishment of the Research Triangle Park which is a cooperative effort between the three major universities—Duke, North Carolina State, and Chapel Hill. The $1 million in seed money has led to what is now a $1 billion investment.

The establishment of the park was based on several continuing realities.

First, North Carolina universities, at great expense to the State, were turning out many highly qualified graduates in science and engineering who were leaving the State because few employment opportunities existed.

Second, North Carolina was experiencing erosion of its basic industries of apparel, textiles, tobacco, and to some extent, furniture. The recognition of these realities and the farsighted convictions and aggressive attitudes on the part of public officials, universities and private industry has been an essential element in the formulation of an integrated North Carolina strategy for technology innovation.

The North Carolina long-term strategy for modern economic development is based on three general principles. First, a healthy economic environment based on a constitutionally mandated balanced budget. We find that companies coming in regard that as a very positive factor. Second, a carefully structured program to ensure an adequate internal structure for the support of industry.

And, third, and the subject of my comments this morning, a major set of programs to support all elements of education with special programs to reinforce high priority research and technology and the environment thereof, with universities in the State. The Joint Economic Committee report on industry location stressed the importance of the academic element in new plant locations and technology development. As an individual who has been responsible for locating high technology industry, I found that to be an extremely important element.

The North Carolina General Assembly has supported the State education and technology strategy with very substantial funding commitments. Recognizing the reinforcement of the public school system as a basic foundation of economic development, the general assembly added $280 million to the $1.4 billion annual base budget for this new fiscal year. That is a supplementary budget addition.

Special technology innovation programs launched by North Carolina leaders since 1983 include new State appropriations of more than $160 million. In the 1984-85 fiscal year alone the State has committed $106 million to expand technology related research, education and training programs.

The total 2-year expenditures include these three major elements. The first element of modern technical education included $88 million for the community college system. The North Carolina Community College system includes 58 campuses across the State; 90 percent of the population is within commuting distance of one of these community colleges and 600,000 citizens participate each year in their educational programs.

The programs are continually updated to include the skills necessary to support new technology industry. Working closely with industry, individual training programs are custom designed for existing and new industries to prepare workers for specific high technology jobs. I might add that when I located a major integrated circuit facility in North Carolina they promised me I'd have all the talent I needed when we opened the doors and they met that promise and made it a very successful start up.

The second element is higher education and training; $27 million has been provided in the last 2 years for new university engineering computer science buildings. A major goal has been established to improve quality and quantity of graduate programs in science and engineering at North Carolina universities by accelerating new building programs. These new facilities are essential for providing talent for supporting innovation requirements in basic industry as well as new high technology industry.

The third element is State-sponsored research centers and we're somewhat unique here I believe; $32 million in the last 2 years for the North Carolina Biotechnology Center and the Microelectronics Center of North Carolina, related facilities, research programs and operations. North Carolina has established two major research centers. The Microelectronics Center of North Carolina and the Biotechnology Center.

I direct the Microelectronics Center of North Carolina where we've established a major national resource for modern electronics by combining the microelectronics resources of five universities; the three triangle universities, North Carolina University, A&T, the black university at Greensboro, and the University of North Carolina at Charlotte. Our consortium also includes the Research Triangle Institute which is located in the Research Triangle Park.

With State support of $46 million today and strong industrial participation, the center is a unique technology transfer mechanism dedicated to achieving next generation microelectronics manufacturing technology that will benefit North Carolina and the Nation. I might point out that this is a unique State funded situation. There is no national laboratory for microelectronics even though it is a most pervasive technology and influences many segments of American industry.

I might add that I'm now evaluating a Canadian proposal to establish two such university based centers specifically for technology transfer to industry. The use of separate entities for this purpose tends to obviate any undesirable impacts on the university educational roles.

While the North Carolina microelectronics program has been achieved without Federal support to date, but there are opportunities for creative Federal involvement, particularly with regard to technology support for small businesses. With minimal incremental Federal support, existing technology centers such as ours in cooperation with universities such as MIT, Cornell, Arizona, Texas, Stanford, Carnegie Mellon, Rensselear, Utah, and others could play an even more important role of meeting the international challenge to U.S. supremacy in technology innovation in the important field of modern electronics.

Such a program could support the technology needs of the hundreds, if not thousands, of critically important emerging small businesses in modern electronics and related areas. These small businesses cannot afford involvement in the expensive joint development companies being formed by large U.S. electronic firms to maintain their own competitive positions. The same needs and opportunities for small business will evolve in other fields, such as biotechnology in the future.

With regard to small business innovation, for nearly 30 years the State of North Carolina has implemented one of the most effective programs for technology innovation and industrial development. The State has already experienced considerable success in attracting high technology industry to the State. Over the past 5 years, high technology industry has invested over $3 billion in new plants and facilities. I might add, since the MCC location competition, North Carolina was one of the final four contestants, North Carolina has acquired over $300 million of new high-technology industry capital, in just a little over a year, and 3,000 jobs without having to buy companies to come into the State.

Public and private investment in research and development in North Carolina now total more than $600 million per year. Those investments in R&D must also result in increased development of new spinoff companies in order to stimulate additional use of technology to further economic growth.

Therefore, the next phase in our development strategy is greater emphasis and entrepreneurship in small business innovation. We are encouraging the startup of new firms through three basic mechanisms: A State initiative, increased support of a Federal program, and private investment. We have developed and established a Technological Development Authority which is currently helping local communities establish incubator facilities to nurture new firms and to provide innovation funding, as some other States are doing, and our budget will be double this coming year.

The State also helps North Carolina firms participate more effectively in the small business innovation research, SBIR program. In the first round of the program, North Carolina firms won 18 awards amounting to almost $800,000 with an award ratio of one in six, one of the best in the Nation.

By the way, the SBIR program could benefit from even more active State involvement. As the Federal funding for SBIR expands by more than a factor of 10 by 1987, to $450 million, to support small business, there's a major role for the States to encourage and to help educate people in making more effective proposals.

The private sector is also recognizing the tremendous potential that exists in the technology change taking place in North Carolina. Venture capital funds from outside the State are now showing interest and there are internal initiatives to develop capital, but increased availability of venture capital is a continuing need in North Carolina as in other technology growth States. North Carolina is also examining the appropriate use of State pension funds for venture support as other States are doing.

And now some comments concerning the Federal role in innovation. The Government must insure the opportunity for all its people to function effectively in today's society. State and local governments are closest to the people and therefore have the primary responsibility to provide the environment for technological innovation and the resulting jobs.

North Carolina's very substantial investment and technology structure have provided the essential base for the facilities programs and environment essential for its own technological vitality. The collective efforts of all the States results in the vitality of the Nation.

So, what then should be the Federal role? I believe that the Federal Government should be supportive of technological innovation in the commercial sector, that Federal policy should be supportive of State initiatives and contribute to the overall environment that encourages innovation.

Federal policies and programs generally should do the following: First, provide increased support to basic, nondefense research at our universities that leads to new discoveries, expands our knowledge base, and supports national objectives of continued world leadership in technology and its application.

Second, develop new mechanisms for the accelerated transfer of technology from the enormous R&D expenditures in the national laboratories, national defense, and space to commercial uses with major emphasis on making this technology accessible by small business. It's interesting to note that the 700 national laboratories, have a budget of approximately $6 billion, which is approximately the entire amount spent by the top 50 universities in research and development across the country.

Third, selectively leverage State investments, with industry support, to achieve faster results in technology development and application, particularly where States cannot fund the total level of excellence to support key technologies of national interest.

Fourth, through tax and other incentives, encourage industry to provide broader support to university research well beyond the 4 percent industry currently supports. Consider tax provisions that would give full recognition to the value of new structural mechanisms such as university related nonprofit educational and research organizations.

Fifth, support modern technology education and research equipment requirements at universities where today the equipment is woefully obsolete, with little hope of this critical situation being rectified in the short term. The resolution of this issue is extremely important if we are to develop the quantity and quality of talent to support the increasingly complex job of meaningful technological innovation and economic development.

Let me conclude my testimony by emphasizing that North Carolina's investments in technology innovation are regarded just as fundamental business investments in the future of the State. Individual and collective leadership by governors, State legislators and university and business executives continues to be the primary factor in North Carolina's success in supporting such investments for technological innovation and economic redevelopment.

I thank you for this opportunity.

[The prepared statement of Mr. Beilman follows:]

PREPARED STATEMENT OF DONALD S. BEILMAN

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE, THANK YOU FOR THIS OPPORTUNITY TO EXPRESS MY VIEWS ON STATE STRATEGIES FOR IMPROVING THE ECONOMIC CLIMATE FOR INNOVATION AND GROWTH. WE ARE PROUD OF OUR ACCOMPLISHMENTS IN NORTH CAROLINA AND HOPE OUR EXPERIENCES AND APPROACHES WILL BE OF VALUE TO THE COMMITTEE AND OTHERS INTERESTED IN THIS IMPORTANT STRATEGIC AREA.

AS I HAVE PREPARED THIS STATEMENT, I HAVE TRIED TO INCORPORATE MY VIEWS CURRENTLY AS THE PRESIDENT OF THE MICROELECTRONICS CENTER OF NORTH CAROLINA, AS WELL AS MY RECENT EXPERIENCE AS A BUSINESS EXECUTIVE IN HIGH TECHNOLOGY INDUSTRY.

INTRODUCTION

IT IS GENERALLY ACCEPTED THAT INTERNATIONAL COMPETITION FOR TECHNOLOGY LEADERSHIP HAS NEVER BEEN MORE INTENSE.

THE UNITED STATES HAS MAINTAINED ITS LEADERSHIP IN TECHNOLOGY BY PROVIDING A PERMISSIVE ENVIRONMENT IN WHICH TO FOSTER NEW IDEAS AND INNOVATIONS. THE CHALLENGE NOW BEFORE US IS TO DEVELOP A HEIGHTENED ENVIRONMENT TO MEET THE MORE INTENSIVE INTERNATIONAL COMPETITION. TOGETHER, GOVERNMENT, BUSINESS AND EDUCATION MUST DEVELOP THIS NEW ENVIRONMENT AND MEET THIS SCIENTIFIC AND ECONOMIC CHALLENGE.

REQUIREMENT FOR TECHNOLOGY INNOVATION

MAINTAINING U. S. SUPREMACY IN TECHNOLOGY INNOVATION IS OF MAJOR NATIONAL AND STATE INTEREST FOR THREE REASONS.

THE FIRST TWO RELATE TO MAINTENANCE OF A LEADERSHIP POSITION IN THE WORLD ECONOMY:

- THE U. S. HAS MAINTAINED A FAVORABLE BALANCE OF TRADE IN HIGH TECHNOLOGY PRODUCTS AND SERVICES. THIS INDUSTRIAL SEGMENT IS PARTICULARLY IMPORTANT TO U. S. ECONOMIC HEALTH, ESPECIALLY WITH THE CONTINUED FOREIGN EROSION OF SOME OF OUR BASIC INDUSTRIES SUCH AS STEEL AND TEXTILES.

- The continued introduction of technology innovation in our basic industries for improved productivity is essential for maintaining significant shares of world markets in these industries.

The third major reason is maintaining our national defense and security which is highly dependent on technological innovation. It is important to note that the defense outlays for R&D are a very substantial 65 to 70% of total federal R&D funds.

My comments today will focus on the first two requirements... how States in general, and North Carolina in particular, have become full partners in promoting and supporting non-defense technology innovation for maintaining world economic leadership.

State Initiatives

Each state has implemented programs which vary from one another, and should, to take advantage of their unique resource base. A discussion paper recently presented at the National Governor's Association identified five common activities that are integrated into most State programs, including North Carolina's:

1. SCIENTIFIC AND ENGINEERING RESOURCES WITHIN UNIVERSITIES ARE BEING BROUGHT INTO CLOSER WORKING RELATIONS WITH THE PRIVATE SECTOR
2. STEPS ARE BEING TAKEN TO STRENGTHEN QUALITY OF RESEARCH AND EDUCATION AT STATE INSTITUTIONS
3. STATE RESOURCES ARE BEING MATCHED WITH FUNDAMENTAL ADVANCES NEEDED IN SCIENCE AND ENGINEERING TO DETERMINE AREAS MOST ADVANTAGEOUS TO THE STATE
4. SUPPORT REQUIREMENTS FOR SMALL BUSINESS DEVELOPMENT ARE BEING DIFFERENTIATED FROM THOSE ESSENTIAL FOR LARGER COMPANIES
5. IMPROVEMENTS ARE BEING MADE IN THE INSTITUTIONAL AND PHYSICAL INFRASTRUCTURE

THE PREDOMINANT MOTIVATION FOR STATE ACTION IS TO DEVELOP CONDITIONS WITHIN EACH STATE WHICH PROVIDE MORE AND BETTER JOBS FOR PEOPLE. THE RESULT IS THAT STATE GOVERNMENTS ARE ASSUMING MORE AND MORE RESPONSIBILITY FOR TECHNOLOGICAL INNOVATIONS.

In 1982 North Carolina Governor James B. Hunt stated that "In matters other than defense and space, the center of gravity for technological innovation must shift from the Federal government to State governments." This process was well underway in North Carolina at that time and has continued to be the policy of our State.

The North Carolina Experience

The evolution of the State of North Carolina to a position of leadership in technological innovation is the result of a consciously structured, coherent statewide strategy. This approach is in contrast to the old fragmented efforts by departments of commerce shotgunning for any and every segment of industry. North Carolina's initiative began nearly 30 years ago with the establishment of the Research Triangle Park, a cooperative effort between the State and the Research Triangle universities (Duke University, North Carolina State University, and the University of North Carolina at Chapel Hill). One million dollars in seed money has led to what is now nearly a billion dollar investment.

The establishment of the Research Triangle Park was based on several continuing relevant realities. First, North Carolina universities, at great expense to the State, were turning out many highly qualified graduates in science and engineering who were leaving the State because few employment opportunities existed. Second, North Carolina was experiencing erosion of its basic industries of apparel, textiles, furniture and tobacco. The recognition of these realities and the farsighted convictions and aggressive attitudes on the part of public officials, universities and private industry has been an essential element in the formulation of an integrated North Carolina strategy for technology innovations.

The North Carolina strategy for technology innovation has depended on and benefitted from several factors:

- Strong top-down State leadership - Governors and General Assembly members
- Active participation of universities
- Strong business community support

THE STRONG LEADERSHIP DEMONSTRATED BY EACH OF THESE SECTORS SEPARATELY AND IN COLLABORATION HAS BEEN THE KEY TO NORTH CAROLINA'S SUCCESS.

THE NORTH CAROLINA STRATEGY FOR MODERN ECONOMIC DEVELOPMENT IS BASED ON THREE GENERAL PRINCIPLES:

1ST - A HEALTHY ECONOMIC ENVIRONMENT BASED ON A CONSTITUTIONALLY MANDATED BALANCED BUDGET.

2ND - A CAREFULLY STRUCTURED PROGRAM TO INSURE AN ADEQUATE INTERNAL STRUCTURE FOR TRANSPORATION, UTILITIES AND FINANCE.

AND 3RD - A MAJOR SET OF PROGRAMS TO SUPPORT ALL ELEMENTS OF EDUCATION WITH SPECIAL PROGRAMS TO REINFORCE HIGH PRIORITY RESEARCH AND TECHNOLOGY WITH UNIVERSITIES IN THE STATE.

THE NORTH CAROLINA GENERAL ASSEMBLY HAS SUPPORTED THE STATE EDUCATION AND TECHNOLOGY STRATEGY WITH VERY SUBSTANTIAL FUNDING COMMITMENTS. RECOGNIZING THE REINFORCEMENT OF THE PUBLIC SCHOOL SYSTEM AS A BASIC FOUNDATION OF ECONOMIC REDEVELOPMENT, THE

General Assembly added $280 Million to the $1.4 Billion annual base budget for this new fiscal year.

Special technology innovation programs launched by North Carolina leaders since 1983 include new State appropriations of more than $160 million. In the 1984-85 fiscal year alone the State has committed an *additional* $106 Million to expand technology-related research, education and training programs. The *total* two year expenditures include:

- *Modern Technical Education* - $88 Million for the Community College System.

The North Carolina Community College System includes 58 campuses across the State. 90% of the population is within commuting distance of one of these Community Colleges and 600,000 citizens participate each year in their educational programs. Programs are continually updated to include the skills necessary to support new technology industry. Working closely with industry, individual training programs are designed for existing and new industries to prepare workers for high technology jobs.

- HIGHER EDUCATION AND TRAINING - $27.4 MILLION FOR UNIVERSITY ENGINEERING AND COMPUTER SCIENCE BUILDINGS

A MAJOR GOAL HAS BEEN ESTABLISHED TO IMPROVE QUALITY AND QUANTITY OF OUTPUT OF GRADUATE PROGRAMS IN SCIENCE AND ENGINEERING AT NORTH CAROLINA UNIVERSITIES. THIS IS ESSENTIAL FOR PROVIDING TALENT FOR SUPPORTING INNOVATION REQUIREMENTS IN BASIC, AS WELL AS NEW HIGH TECHNOLOGY INDUSTRY.

- STATE SPONSORED RESEARCH CENTERS - $32 MILLION FOR THE NORTH CAROLINA BIOTECHNOLOGY CENTER AND THE MICROELECTRONICS CENTER OF NORTH CAROLINA RELATED FACILITIES, RESEARCH PROGRAMS AND OPERATIONS

NORTH CAROLINA HAS ESTABLISHED TWO MAJOR RESEARCH CENTERS, THE MICROELECTRONICS CENTER OF NORTH CAROLINA (MCNC), AND THE NORTH CAROLINA BIOTECHNOLOGY CENTER. MCNC, WHICH I DIRECT, HAS ESTABLISHED ITSELF AS A MAJOR NATIONAL RESOURCE FOR MODERN ELECTRONICS BY COMBINING THE MICROELECTRONICS RESOURCES OF THE FIVE UNIVERSITIES (DUKE UNIVERSITY, NORTH CAROLINA A&T STATE UNIVERSITY, NORTH CAROLINA STATE UNIVERSITY, UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL, UNIVERSITY OF NORTH CAROLINA AT

CHARLOTTE) AND THE RESEARCH TRIANGLE INSTITUTE. WITH STATE SUPPORT OF $46 MILLION TO DATE, AND STRONG INDUSTRIAL PARTICIPATION, MCNC IS A UNIQUE TECHNOLOGY TRANSFER MECHANISM DEDICATED TO ACHIEVING NEXT GENERATION MICROELECTRONICS MANUFACTURING TECHNOLOGY THAT WILL BENEFIT NORTH CAROLINA AND THE NATION. WHILE THIS HAS ALL BEEN ACHIEVED WITHOUT FEDERAL SUPPORT TO DATE, THERE ARE OPPORTUNITIES FOR CREATIVE FEDERAL INVOLVEMENT PARTICULARLY WITH REGARD TO TECHNOLOGY SUPPORT FOR SMALL BUSINESSES.

WITH MINIMAL INCREMENTAL FEDERAL SUPPORT, EXISTING TECHNOLOGY CENTERS, SUCH AS OURS, IN COOPERATION WITH UNIVERSITIES SUCH AS MIT, CORNELL, ARIZONA, TEXAS, STANFORD, UTAH, CARNEGIE MELLON, RENSSELAER POLYTECHNIC INSTITUTE, AND OTHERS, COULD PLAY AN EVEN MORE IMPORTANT ROLE IN MEETING THE INTERNATIONAL CHALLENGE TO U. S. SUPREMACY IN TECHNOLOGY INNOVATION IN THE IMPORTANT FIELD OF MODERN ELECTRONICS.

Such a program could support the technology needs of the hundreds of critically important emerging and small businesses that cannot afford involvement in the expensive joint development companies being formed by large U. S. electronic firms to maintain their competitive positions. The same needs and opportunities will evolve in other fields such as biotechnology in the future.

Small Business and Innovation

For nearly thirty years, the State of North Carolina has implemented one of the strongest programs for technology innovation in the world. The State has already experienced considerable success in attracting high technology to the State; over the past five years high technology industry has invested over $3 Billion in new plants and facilities.

Public and private investment in research and development in North Carolina now totals more than $600 Million per year. Those investments in R&D must also result in increased development of new spinoff companies in order to stimulate additional use of technology and further economic growth.

THEREFORE, THE NEXT PHASE IN OUR DEVELOPMENT STRATEGY IS GREATER EMPHASIS ON ENTREPRENEURSHIP AND SMALL BUSINESS INNOVATION.

THE STATE OF NORTH CAROLINA IS ENCOURAGING THE START-UP OF NEW FIRMS THROUGH THREE BASIC MECHANISMS: A STATE INITIATIVE, INCREASED SUPPORT OF A FEDERAL PROGRAM AND PRIVATE INVESTMENT.

- NORTH CAROLINA HAS ESTABLISHED A TECHNOLOGICAL DEVELOPMENT AUTHORITY (TDA) WHICH IS CURRENTLY HELPING LOCAL COMMUNITIES ESTABLISH INCUBATOR FACILITIES TO NURTURE NEW FIRMS. LAST YEAR, ITS FIRST YEAR, TDA INVESTED STATE MONEY IN FIVE NEW VENTURES ($225,000 IN TOTAL). THE BUDGET HAS MORE THAN DOUBLED THIS YEAR, AND THE INVESTMENT WILL BE RECOVERED WITH INTEREST WHEN THE VENTURES ARE SUCCESSFUL.
- THE STATE HELPS NORTH CAROLINA FIRMS PARTICIPATE IN THE SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM. IN THE FIRST ROUND OF THE PROGRAM, NORTH CAROLINA FIRMS WON 18 AWARDS AMOUNTING TO $778,265. THE AWARD RATIO WAS 1 IN 6, ONE OF THE BEST IN THE NATION. BY THE WAY, IN THE

OPINION OF MANY, THE SBIR PROGRAM COULD BENEFIT FROM MORE ACTIVE STATE INVOLVEMENT.

. THE PRIVATE SECTOR IS ALSO RECOGNIZING THE TREMENDOUS POTENTIAL THAT EXISTS IN THE TECHNOLOGICAL INFRASTRUCTURE OF NORTH CAROLINA. VENTURE CAPITAL FUNDS FROM OUTSIDE THE STATE ARE NOW SHOWING INTEREST IN NORTH CAROLINA AND INITIATIVES TO DEVELOP IN-STATE VENTURE CAPITAL ARE UNDERWAY. INCREASED AVAILABILITY OF VENTURE CAPITAL IS A CONTINUING NEED IN NORTH CAROLINA AS IN OTHER TECHNOLOGY GROWTH STATES.

FEDERAL ROLE

GOVERNMENT MUST INSURE THE OPPORTUNITY FOR ALL OF ITS PEOPLE TO FUNCTION EFFECTIVELY IN TODAY'S SOCIETY. STATE AND LOCAL GOVERNMENTS ARE CLOSEST TO THE PEOPLE AND THEREFORE HAVE THE PRIMARY RESPONSIBILITY TO PROVIDE THE ENVIRONMENT FOR TECHNOLOGICAL INNOVATION AND THE RESULTING JOBS. NORTH CAROLINA'S VERY SUBSTANTIAL INVESTMENTS IN TECHNOLOGY STRUCTURE HAVE PROVIDED THE ESSENTIAL BASE FOR THE FACILITIES, PROGRAMS, AND ENVIRONMENT

ESSENTIAL FOR ITS OWN TECHNOLOGICAL VITALITY. THE COLLECTIVE EFFORTS OF ALL STATES RESULTS IN THE VITALITY OF THE NATION.

"WHAT THEN SHOULD BE THE FEDERAL ROLE?"

I BELIEVE THAT THE FEDERAL GOVERNMENT SHOULD BE SUPPORTIVE OF TECHNOLOGICAL INNOVATION IN THE COMMERCIAL SECTOR, THAT FEDERAL POLICIES SHOULD BE SUPPORTIVE OF STATE INITIATIVES AND CONTRIBUTE TO THE OVERALL ENVIRONMENT THAT ENCOURAGES INNOVATION.

FEDERAL POLICIES AND PROGRAMS GENERALLY SHOULD:

1ST. PROVIDE INCREASED SUPPORT TO BASIC NON-DEFENSE RESEARCH AT OUR UNIVERSITIES THAT LEADS TO NEW DISCOVERIES, EXPANDS OUR KNOWLEDGE BASE AND SUPPORTS NATIONAL OBJECTIVES OF CONTINUED WORLD LEADERSHIP IN TECHNOLOGY AND ITS APPLICATIONS.

2ND. DEVELOP NEW MECHANISMS FOR THE ACCELERATED TRANSFER OF TECHNOLOGY FROM THE ENORMOUS R&D EXPENDITURES IN NATIONAL DEFENSE AND SPACE TO COMMERCIAL USES WITH MAJOR EMPHASIS ON MAKING THIS TECHNOLOGY ACCESSIBLE BY SMALL BUSINESSES.

3RD. SELECTIVELY LEVERAGE STATE INVESTMENTS, WITH INDUSTRY SUPPORT, TO ACHIEVE FASTER RESULTS IN TECHNOLOGY DEVELOPMENT AND APPLICATION WHERE STATES CANNOT FUND THE TOTAL LEVEL OF EXCELLENCE TO SUPPORT KEY TECHNOLOGIES OF NATIONAL INTEREST.

4TH. THROUGH TAX AND OTHER INCENTIVES ENCOURAGE INDUSTRY TO PROVIDE BROADER SUPPORT TO UNIVERSITY RESEARCH WELL BEYOND THE 4% INDUSTRY CURRENTLY SUPPORTS. CONSIDER TAX PROVISIONS THAT WOULD GIVE FULL RECOGNITION TO THE VALUE OF NEW STRUCTURED MECHANISMS SUCH AS UNIVERSITY RELATED NON-PROFIT EDUCATIONAL AND RESEARCH ORGANIZATIONS.

5TH. SUPPORT MODERN TECHNOLOGY EDUCATION AND RESEARCH EQUIPMENT REQUIREMENTS AT UNIVERSITIES WHERE TODAY THE EQUIPMENT IS WOEFULLY OBSOLETE, WITH LITTLE HOPE OF THIS CRITICAL SITUATION BEING RECTIFIED. THE RESOLUTION OF THIS ISSUE IS EXTREMELY IMPORTANT IF WE ARE TO DEVELOP THE QUANTITY AND QUALITY OF

TALENT TO SUPPORT THE INCREASINGLY COMPLEX JOB OF MEANINGFUL TECHNOLOGICAL INNOVATION AND ECONOMIC DEVELOPMENT.

CONCLUSION

LET ME CONCLUDE MY PREPARED COMMENTS BY EMPHASIZING THAT INVESTMENTS IN TECHNOLOGY INNOVATION ARE JUST FUNDAMENTAL INVESTMENTS IN THE FUTURE OF EACH STATE AND THE NATION.

THE KEY TO SUCCESSFUL INVESTMENT IN TECHNOLOGY IS LEADERSHIP.

INDIVIDUAL LEADERSHIP BY GOVERNORS, STATE LEGISLATURES UNIVERSITY AND BUSINESS EXECUTIVES CONTINUES TO BE THE PRIMARY FACTOR IN NORTH CAROLINA'S SUCCESS IN SUPPORTING TECHNOLOGICAL INNOVATION AND ECONOMIC REDEVELOPMENT.

THANK YOU FOR THE OPPORTUNITY TO APPEAR BEFORE YOU TODAY.

Representative LUNGREN. Thank you very much, Mr. Beilman. Mr. Brennan.

STATEMENT OF PETER J. BRENNAN, PARTNER, BRENNAN & GARSON, NEW YORK, NY

Mr. BRENNAN. Thank you, Congressman Lungren.

You'll be pleased to know that your opening remarks have considerably shortened mine.

I will touch upon the varied nature of advanced technology industry as this relates to site selection. I will mention a few case histories to both challenge and support the conventional wisdom and show that almost any place can generate new industry provided the area appeals to the right person.

My prepared statement covers these matters in much greater detail than these remarks.

To generate a true advanced technology center of any size, even to make an area attractive for a high technology assembly organization, is a long-term job. Institutional attitudes do not change over night. School systems are not built in a day. Conservative bankers whose horizons extend only to home or farm mortgages usually do not suddenly become venture capitalists. Skilled mechanics whose previous practice involved tractors and combines may take a while to learn how to maintain high vacuum pumps under clean room conditions. Former textile millhands may at first be a little clumsy with printed circuits and microchips.

There's high tech and there's high tech. You have to define which kind you're talking about and trying to attract or generate and what you hope that type of industry will do for your region. It makes a big difference to a community whether the technology industry is locally innovated or transplanted from elsewhere.

Three factors give birth to and nurture advanced technology industries. These are: One, the innovative individual; two, finance; and three, the community. Other factors are important. As a study by the Office of Technology Assessment says, it doesn't hurt to have a major university.

Leaps in technology require first the quantum jumps and imagination of which a few remarkable people are capable. Recognition of this factor seems conspicuously absent from most of the studies and reports I have seen. This innovative individual can exist anywhere and go anywhere. The climate or environment that produced him or her and in which he works may or may not be important.

Ken Susnjara, founder and president of Thermwood Corp., a robotics manufacturer in Dale, IN, has strong opinions on these factors. He says:

> The top one half of one percent of research people produce the new ideas. The key to success is to latch on to one of them. Then it takes a half dozen people to make the concept work.

He's not alone. For Cliff Williams who established International Senson Systems in a cow pasture near Aurora, NE, the key was imported talent. He paid high salaries to a cadre of five experts from all over the country to help set up his company. Another promoter I knew in San Diego once said to me, "Give me a superb engineer and a good idea and I'll found a successful company anywhere, but he has to be a superb engineer."

The second essential is capital. One wonders some times if the importance of local availability of large capital pools has not been overemphasized. And which came first, the technology or the capital? In the beginning one suspects it was the technology, financed by the inventor's friends and relatives. It has been said that wherever there is a good idea, capital will be found to fund it. Ken Susnjara, as well as many others I have talked to, agree. He says, for the entrepreneur money is at the top of the hierarchy, which explains the general emphasis on venture capital.

But then, he went on to say, personnel comes second, but since the money is available anywhere, he says, contradicting the coventional wisdom, we must go where the people are who can do what we want. Once you have the people, the capital follows.

Most of the rapidly growing companies I talked to in out-of-the-way places bootstrapped their companies and successfully acquired debt rather than equity financing.

The third factor is community. Any community can provide the infrastructure to attract and maintain companies that manufacture goods based on advanced technology developed elsewhere. These are assembly operations which are not site-dependent. When an area seeks to attract such industries, it competes with every other State and a couple of hundred nations. Each can and will manipulate and tailor its local attributes to match the competition. A region will attract some industries and lose others on factors beyond its control. The site location manager might prefer surfing to mountaineering or the chairman likes golfing, hunting, canoeing, or trout fishing.

Mr. Harold Lonsdale started Bend Research, which works with exotic membranes, in tiny Bend, OR, because he is an avid fly fisherman. James Jubb moved to his vacation land, Montana, to establish Spectrum Enterprises. Why Montana? "Midlife change," he told me.

How does a development agency divine and capitalize on a budding entrepreneur's midlife change?

The conventional wisdom says that first-rate universities are essential to sparking the innovative explosion. The university connection may, indeed, be essential to the eventual rise of a technology cluster, but it is not clear that universities are essential to the spontaneous budding of new companies.

Edward Moore, cofounder and president of Wilmore Electronics in Durham, NC, told me lots of companies like Wilmore end up where they are because there is an educational institution. On the other hand, says Thermwood's Susnjara, "Universities are not important until you're a $100 million company, except as a source of people. In the earlier stages, you're not paying much attention to 7 years ahead where the university is thinking."

Tom Moore, chairman and founder of Intelect Corp. in Honolulu, speaking of the University of Hawaii, said to me: "We look upon it as a potential resource."

James Jubb of Spectrum Enterprises considers the lack of a nearby university a minor drawback. "The nearest one is 400 miles away," he said. "We can't take evening classes or attend seminars."

Let's look at some entrepreneurial companies that defy the conventional wisdom by locating in lesser known places.

Interestingly, the governors of State development agencies put me in contact with most of these entrepreneurs, hoping, I expect, that the interviewees would say great things about their States.

They were disappointed. Most of these people said little or nothing about State programs. If there is a common thread to their individual decisions to locate where they are, it reflects a highly personal desire for a quality of life which is quite beyond any quick fix a State can make.

The smaller growing company may not have much interest in the traditional incentives. Thermwood, for example, paid little attention to them. "Startup companies don't make much money for the first 5 years," the president told me, "So tax incentives don't help much. Rent incentives, job training, would be useful to the mature company, but not to us."

Not-yet-born companies are not usually the target of development agencies, partly because no one can foretell them. Nor do budding entrepreneurs move from one location to another just to start a company. Some do. Cliff Williams did, to Nebraska. So did James Jubb. But Edward Moore started his business in North Carolina because he got his graduate degree there. Tom and Lucille

Moore in Hawaii didn't want to go home to New Jersey. It wasn't incentives that attracted these people but personal imperatives that drove them. They're awfully hard for an industrial development department to identify before they start.

One factor a development agency can control is attitude. An eager attitude won International Data Systems for San Diego, while an offhand air did not attract ETA Systems from Minnesota to elsewhere.

Lloyd Thorndyke, president and chief executive offices of ETA, recently spun off from Control Data to develop supercomputers, said of other areas, "They took the attitude that if we wanted to locate there, it was okay with them, but they didn't bust themselves for us."

Says Harold Georgems, founder of International Data Systems, "The key factor in our decision was the willingness of the community in San Diego to help, not with material incentives—there were none—but the degree to which the San Diego economic development people worked with us."

In North Carolina, Edward Moore of Wilmore Electronics has benefited from the infrastructure generated by the Research Triangle. A native of Virginia, a graduate of Virginia Tech, Moore went to North Carolina's Duke University for his doctorate. There a group of professors and graduate students dreamed up a company to manufacture power suppliers for computer systems.

Dr. Moore said:

> It was really the university situation which got things started, and without the Research Triangle, we would not have the airline connections. It has created a pool of trained and skilled technical people that we don't have to educate to our needs.

Others have to create their own environment. Cliff Williams runs International Sensor Systems from a former cow pasture in Aurora, NE. The company is at the very leading edge of hybrid thick-film technology. Williams, who came originally from the State and graduated from the University of Nebraska, told me he had some real qualms about moving there. Then a Connecticut resident, Williams planned to start his company in Connecticut and had even begun negotiations with the Connecticut Development Corp. He came out to Nebraska on a family visit.

Says Williams:

> Local bankers wanted me to start the business in Aurora. I couldn't even think of it. Nobody knew the technology. I got a call from Harold Edgerton, inventor of the stroboscope, and a native Nebraskan. The banker had put him on to me.
>
> I agreed to look the State over. The main thing would be people—not even the university had ever heard of thick-film technology. But as I examined the area, I became impressed with the attitude of the people. So I called Edgerton and said if he would be on my board, I would start the company in Aurora. He agreed, and here we are.

Thermwood, in Indiana, is where it is and remains there, because Indiana is home. But the company does its R&D and marketing from Dallas, TX. As a new factor in a frontier industry, robotics, Thermwood needed to find the right people for its R&D. "We used an executive search firm to determine where the people we wanted are," Mr. Susnjara told me.

Jim Jubb moved from St. Louis to Montana to set up his company.

> Electronics companies aren't really sensitive to geography. The cost of freight for electronic products is negligible. We have no trouble getting competent people from all over.

Nor has Spectrum had difficulty obtaining money. The company has been financed almost entirely by loans from the local Security State Bank.

Montana's efforts to attract and develop advanced technology industry had nothing to do with Jubb's decision to locate there.

> We could have financed part of our capital assess through revenue bonds, but the timing was wrong. We can also get fixed interest loans through the Build Montana programs, but we haven't done so.

Hal Georgems of Long Island, NY, gradually migrated westward. When at Bell & Howell in Pasadena, Mr. Georgems decided to start his own company to make small tape drives. "We started in rented space across the street from Bell & Howell, because that's where I was," he said.

Five years later, the company filled three buildings.

> We would have to relocate. We looked at Oregon, Austin, Boulder, but it didn't seem to make any sense to move that far. We drew a 100-mile radius around Pasadena. What with one thing and another, we set up new facilities in San Diego and phased out the Pasadena operations.

Pasadena is the site of the California Institute of Technology and the Jet Propulsion Laboratory, tremendous technical resources. International Data would have been happy to stay there, but Georgems told me the city gave little encouragement. There is a moral there.

Geographic isolation is no bar to advanced technology industry. You can't go much further and still be in the United States than Hawaii. Hawaii's legislature has established a high technology development corporation and has also established at the university, the Pacific Internal Center for High Technology.

But the founders of Intelect Corp. didn't care about all that. New Jersey natives, Thomas and Lucille Moore started the company on returning from assignment in Singapore. Mr. Moore told me:

> All of a sudden, we could see that it no longer mattered where you were with the microchip, we had a modest pool of capital and didn't want to go back to the mainland. If you stay with high technology products, you can build them anywhere. What makes the real difference is how clever the people are. And we found here a hidden pool of talent.

Other than as a once-removed source of engineering staff, however, the university has not been important to the company.

When routine quality control is a step beyond what rigorous scientific procedures were a few years ago, what must be the level of science needed to support and advance today's manufacturing processes? Do those who devise quality control procedures have advanced degrees, what level of people must the company have to improve the manufacturing process or devise new ones? With whom do these people wish to associate? What do they do in their spare time? How do they renew and update their basic skills and knowledge? What serendipitous associations and contacts spark their imaginations and lead them on to breakthroughs that are the essence of innovative technology?

The best answer to those questions is community. That means all the factors taken together that appeal to, cradle and stimulate the creative talents of exceptionally gifted people. For some that's a beach, a trout stream or Glacier National Park. For others it is proximity to a major urban center or to large numbers of their fellows. A great university is not essential. A good one that is of and not merely in the community, certainly is.

Perhaps the distinguishing feature of a true innovative technology center is, indeed, a university, but not one in the usual sense. If a university is a community of scholars, then perhaps an advanced technology center is itself a university, a community of scholarly companies.

The usual incentives will attract, to any region, its fair share of transplanted technology. To attract more than its share of innovative technology, however, an area must foster any environment that will attract and hold the people who dream it up. It can't be done overnight and possibly not at all artificially. No one planned the existing innovative centers.

That concludes my testimony.

[The prepared statement of Mr. Brennan, together with an attachment, follows:]

Prepared Statement of Peter J. Brennan

Some Encouraging Examples
that
Challenge The Conventional Wisdom

Thank you Congressman Lungren. It is indeed a pleasure to be part of so distinguished a company.

I hope that my remarks may add something of value to the current national debate on how best to increase the net sum of jobs and industry throughout the United States, not just in a few well-favored areas.

Since I do not represent any state, my presentation will not directly address the questions suggested for witnesses that the Committee distributed earlier. Nor will I repeat the data generated by the many excellent reports and studies on this subject prepared by the staff of the Joint Committee as well as those of the National Governors Association, the Office of Technology Assessment, the Council of State Planning Agencies, the National Association of State Development Agencies and those of the many states themselves as well as private organizations such as the Fantus Company in Chicago.

Rather, I will touch upon the varied nature of advanced technology industry as this relates to site selection by these industries. I will mention a few case histories that both challenge and support the conventional wisdom and show that almost anyplace can generate new industry, provided the area appeals to the right person.

The concern with advanced technology, entrepreneurship, fostering of homegrown companies rather than buying-in of industry from other states and localities is a fairly recent one. In interviews only last month I was told that the primary mechanism for increasing industry and developing new jobs remains the package of economic incentives that one state or locality hopes will lure an existing industry from another state or locality.

States and localities have always competed vigorously with one another to attract industry from other areas. Competitive incentives are standard. But many have begun to question the national and even local benefit gained by merely moving an established enterprise from one area to another -- promoting runaway industry -- often at great cost to taxpayers in both old and new locations. "Persuading an established company to move from one location to another is a zero-sum game with no net gain for the nation," said one Governor at the 1984 National Governors Conference here in Washington. I am sure that many witnesses before this committee have addressed this very point.

I know the concerns of many states, which fear being left behind on the high technology wave of the future, which look with envy at the accomplishments of such area as the Santa Clara Valley in California, better known as Silicon Valley, and the Route 128 phenomenon in Massachusetts. I see many misconceptions about high technology itself -- its nature, where it flourishes and where not, even its applications.

I see much of conventional wisdom, a lot of which is correct. But it also falls short because it occasionally overlooks the role of the individual and fails to distinguish between the various stages of high technology companies. Nor does it always indicate an understanding that technology is not an end in itself but a means to improved productivity, lower costs, a better standard of living.

High technology is improving the shoe industry in Maine, the automotve industry across the country, agriculture in North Dakota. Governor Allen I. Olson of

North Dakota said it well in a letter to me earlier this year. "North Dakota has comparatively few high tech industries," Governor Olson wrote. "Rather, the state has been more of a high-tech user, applying advanced technology to production processes...much of the innovation expressed in north Dakota appears in farm machinery produced in the state. I recognize that this is not considered high tech, but it has enabled the employment of North Dakotans, which is, of course, the goal of technological development and growth."

Over the past several years, as I have researched many articles on domestic and international industrial development, I have interviewed hundreds of people in many countries and in all sorts of industries from amusement parks to cement, from autos to semiconductors. I have also talked to industrial development people, bankers, venture capitalists and public officials. The object was to determine the ingredients of a successful high technology area.

The programs instituted by many states, designed to identify potential entrepreneurs, nurture them and give rise to healthy local industries are steps in the right direction. But their proponents should not expect quick results, nor should they expect to replicate

Silicon Valley and Route 128. Each of those is unique. Each new center is unique and all those to come will be unique. The task the states face is to define for themselves those characteristics that they either have or can develop which will allow new businesses to germinate, take root and grow on their own soil.

The Office of Technology Assessment (OTA) of the U.S. Congress cites several factors for successful nurturing of high technology. These include a strong research university; skilled labor pool; available financing; the presence of corporate headquarters; transportation; good climate; cultural amenities. "All may be desirable or necessary factors," says OTA, "but they are not always enough." Indeed, usually, they are not nearly enough.

The OTA study suggests a most important additional factor: identify and focus on local needs and resources rather than copy other states.

To generate a true advanced-technology center of any size, even to make an area attractive to a high-technology assembly organization, is a long-term job. Institutional attitudes do not change overnight. School systems are not built in a day. Conservative bankers whose horizons extend only to home or farm mortgages do not suddenly become risk-taking venture capitalists. Skilled mechanics whose previous practice involved tractors and combines may take a while to learn how to maintain high-vacuum pumps under clean-room conditions. Former textile mill hands may at first be a little clumsy with printed circuit boards and microchips.

Probably best known of the created technology centers in the country is the North Carolina Research Triangle. But it has been nearly thirty years in the making. Even its most ardent supporters acknowledge that only now is the concept first implemented in 1956 at last starting to generate its own growth.

There's high tech and there's high tech. You have to define which kind you're talking about and trying to attract or generate and what you hope that type of industry will do for your region.

Some high technology industry is indeed innovative, generative, the seed for future growth. But a great deal -- most -- of it is no more than tomorrow's assembly line. Jobs, to be sure, but often lower skilled jobs with less community input than the traditional industries they supplant. It makes a big difference to a community whether the technology industry is locally innovative or transplanted from elsewhere.

Understanding the distinctions between transplanted and innovative technology is an essential key to well-planned area development programs. The first brings prosperity but not roots; the second is seed for a future built on products that don't exist or are yet a tiny factor in the economy.

Robert Ady of Fantus Corporation divides high technology industry into three sectors (though his definitions would do for any industry at some stage). He says industries are either theory driven, product driven or market driven.

The first is highly dependent on innovative individuals and a source of scientific input close to hand. The second can be at some remove from the technology base, and is the type of industry most communities think they are getting when the go after high technology. The product-driven industry produces products for market at the leading edge of the technology. Its production facilities still depend on technology input, employ high levels of engineers and scientists and are usually located reasonably close to the company's research and development facilities.

The market driven company, regardless of its level of technology, is cost conscious. It is manufacturing of high technology products in commodity quantities. These facilities do not develop technology, they use it to manufacture products containing it. They are assembly plants. The market driven company employs by far the larger number of people and is least dependent on local technology. It is footloose, far more so than the old smokestack industries.

With exceptions -- aircraft for one -- market driven companies can not only go where they please, they can pack up and move on when local conditions no longer suit them. Witness Atari's shift of manufacturing from California to the Far East.

The traditional industrial bases of many regions are shrinking or moving out. Some areas simply cannot expect their traditional industries ever to recover fully, if they do not fade away completely. Many regions must adapt to, welcome, invite something else, something new.

Today something else invariably means advanced technology. That covers just eight industries: pharmaceuticals, computers, communications, semiconductors, aircraft, and medical, scientific and control instruments. There are smokestack components to each of these. The highly advanced sectors of each actually account for a small percentage of their total output. But the latter are where the future lies.

Once the automobile was high technology. Today, that industry uses technology and is a leading innovator in its own right. In robotics, manufacturing processes, specialized electronics, the automotive industry is an innovator as well as a customer. It is developing a base of knowledge with applications far beyond its own needs. That base is an asset that can lure other industries to auto-making regions. Indiana, for example, has attracted numerous electronic companies to service its automotive-based industries.

Similarly, other industries develop their own applications technology as well as buying it from traditional vendors. No one knows the needs and problems of the food, brewing (among the first mass users and developers of bio-industrial processes, by the way), chemical, mining, forest products, metals, building and furniture industries better than those in it. If these industries don't push the technology to protect their future bottom lines, their competitors will.

Three factors give birth to and nurture advanced technology industries. These are: 1) the innovative individual; 2) finance; and 3) the community. Other factors are important. As the OTA report says, it doesn't hurt to have a major university with lavish research budgets and world-famous faculty in the vicinity, but it's not essential. Well-funded research laboratories can also spew out new technology. Research parks with many research institutes contribute their bit too.

Leaps in technology require first the quantum jumps in imagination of which a few remarkable people are capable. Recognition of this factor seems conspicuously absent from most of the studies and reports I have seen. This innovative individual can exist anywhere, go anywhere. The climate or environment that produced him or her and in which he works may or may not be important.

We can't predict where the seminal innovators, the real geniuses, will appear. We don't know who they might be or what conditions of nature and nurture cause them.

What we do know is that some environments and not others produce more people who carry on and expand the seminal work, the derivative innovators. These people are one step below the authentic and original geniuses. It is not the single genius but large numbers of these second-level innovators that leads to an area's being a center of high technology, of art, science, music or whatever. The environment produces them, sustains and attracts them from elsewhere.

Kenneth Susnjara, a founder and president of Thermwood Corporation, a robotics manufacturer in Dale, Indiana, has strong opinions on these very factors. "The top one half of one percent of research people produce the new ideas," he told me. "The key to success is to latch on to one of them. Then it takes half a dozen people to make the concept work."

Susnjara is not alone. For Cliff Williams, who established International Sensor Systems, Inc., in a cow pasture near Aurora, Nebraska, the key was imported talent. He paid high salaries to a cadre of five experts from all over the country to help set up his company, which is at the leading edge of hybrid thick-film technology. Another promoter I knew in San Diego once said to me: "Give me a superb engineer and a good idea and I'll found a successful company anywhere. But he has to to be a superb engineer."

The second essential is risk capital. If there is one factor that all the innovative compared to derivatory advanced technology centers share it is the ready availability of risk or venture capital. But one wonders sometimes if the local availability of large capital pools has not been overemphasized. And which came first -- the technology or the capital? In the beginning, one suspects, it was the technology, financed by the inventor's friends and relatives.

It has been said that wherever there is a good idea capital will be found to fund it. That's true. Everyone has a family and friends. And Kenneth Susnjara as well as many others I have talked to agree.

"For the entrepreneur, money is at the top of the hierarchy," Susnjara told me, which explains the general emphasis on venture capital. But then he went on to say "Personnel come second. Since the money is available anywhere," he says, contradicting the conventional wisdom, "we must go where people are who can do what we want. Once you have the people, the capital follows."

Cliff Williams got all his financing from kanks. Indeed, most of the rapidly growing companies I talked to in out-of-the-way places bootstrapped their companies and successfully acquired debt rather than equity financing, nor did they have to give their companies away to venture capitalists. My sample is admittedly small, but it is an extraordinarily self-reliant one.

Beyond the startup level, there must also be experienced and venturesome investment bankers. These take a fledgling company across the barrier between local risk capital for a small but growing company to the wider capital sources and services needed by a maturing growth company. Venture capital helps startups; investment capital helps keep them from flying the nest when they grow up.

Venture capital -- the money itself -- need not be local. Money knows neither state nor nationality, only opportunity. Venture money flows into the U.S. from abroad. Thermwood at one point sold 20% of its equity to European investors, which the company later bought back. Money surges from East to West and trickles from money-center cities to small towns. The funds funnel through established venture capital firms into new enterprises wherever those firms are. Local investment companies provide local knowledge and technical expertise as well as willingness to take risks that more conventional funding sources shun.

The third factor is community.

Any community can provide the infrastructure to attract and maintain companies that manufacture goods based on advanced technology developed elsewhere, i.e., transplanted technology. The components inside most home computers or TV sets have "Made in Taiwan, or Singapore, or Malaysia" marked on those tiny, critical, high-technology chips and boards.

These are assembly operations, albeit critical ones that require quality and process control an order of magnitude or more beyond that of the old smokestack industries. These operations are not site dependent. An established manufacturer in any of these advanced technology industries has no compelling reason to put his plant in any one place rather than another.

When an area seeks to attract such industries, it competes with every other state and a couple of hundred nations. Each can and will manipulate and tailor its local attributes to match the competition.

A region will attract some industries and lose others on factors beyond its control. The site location manager might prefer surfing to mountaineering. Or the chairman likes golf, hunting, canoeing or trout fishing. Dr. Harold K. Lonsdale started Bend Research, which works with exotic membranes, in tiny Bend, Oregon, because he is an avid fly fisherman and there are some excellent trout streams in the area.

James R. Jubb, Sr., moved from St. Louis to his vacation land, Montana, where his wife's family lives. Why Montana? "Midlife change," he told me.

How does a development agency divine and capitalize on a budding entrepreneur's midlife change?

The presence of many high-technology manufacturers does not necessarily mean that an area has become or will become a high-technology center. Some nations are sinking under the weight of advanced technology manufacturing industries that their economic development agencies managed to attract. But though many computers have "Made in Ireland" stamped on them, few products have "Invented in Ireland" figuratively stamped on them.

The step between a center of high-technology manufacturing and one of advanced-technology innovation is a long one. No one has adequately defined all the ingredients needed to make that leap.

Some call it critical mass, certainly a term often ectronics in Durham, North Carolina, told me.

On the other hand: "We have some cooperation with local colleges but we don't do a lot with the universities," says Thermwood's Susnjara. "Universities are not important until you're a $100-million company, except as a source of people. In the earlier stages, you're not paying much attention to seven years ahead where the university is thinking. You want a product now and your time frame is 1 to 3 years."

Tom Moore, Chairman and founder of Intelect Corp., Honolulu, speaking of the University of Hawaii, said to me: "We look upon it as a potential resource, while the University itself projects an aura of benign indifference."

James Jubb, Sr., of Spectrum Enterprises in Montana, considers the lack of a nearby university a minor drawback to his rural location. "The nearest one is 400 miles away. We can't take evening classes or attend seminars," he told me.

Let us take a look at some entrepreneurial companies that defy the conventional wisdom by locating in lesser known places, doing without venture capital and the like. These companies exemplify the nature of individual decisions that often reflect personal predilections as much as sound business analysis.

I interviewed their officers because I wanted to know why they located where they did and why they stay where they are. Interestingly, the governors or state development agencies put me in contact with most of these firms, hoping, I expect, that the interviewees would say great things about the states.

They were disappointed. In most cases, these people said little or nothing about state programs. If there is a common thread to their individual decisions to locate where they are, it reflects a highly personal desire for a quality of life which is quite beyond any quick fix a state can make.

Established and growing companies can and do rationally evaluate and decide on new sites. These firms are the proper target of state and regional development agencies.

- The smaller growing company may not have much interest in the traditional incentives. Thermwood Corporation, for example, paid little attention to them. "Startup companies don't make much money for the first five years," the president told me, "so tax incentives don't help much. Rent incentives, job training, would be useful to the mature company, but not us."

Not-yet-born companies are not usually the target of development agencies, partly because no one can foretell them. We know of no development organization that says, in effect, "Entrepreneurs. Start your new business here" as well as "Put your new plant here." Nor do many budding entrepreneurs move from one location to another just to start a company.

Some do. Cliff Williams did, to Nebraska. So did James Jubb, Sr., to Montana. It wasn't incentives that attracted them but personal imperatives that drove them.

Edward Moore started his business in North Carolina because he got his graduate degree there. Tom and Lucille Moore (no relation to Ed) in Hawaii didn't want to go home to New Jersey, but Cliff Williams in Connecticut did. Jim Jubb went to the land of his in-laws, Montana. David Packard met a girl in California and changed his college plans from Colorado. Hal Georgens moved across the street from his former employer in California while Terry Johnson did about the same in Colorado. Neither is a native of those states. Ken Susjnara and Emyre Robinson never left Indiana or Texas resepectively.

These people started new advanced-technology-based companies where they happened to be or wanted to be. They are not unique. They represent a tiny kut typical fraction of the new-technology companies that now generate an ever larger portion of U.S. employment. They exemplify the smaller businesses that employ most U.S. workers. And they are awfully hard for an industrial development department to identify before they start.

Large, established corporations are different. Market factors and internal corporate dynamics determine their moves. When most factors are equal, incentives do play an important role. But the mature company will more likely base its decision on factors inherent to the destination and beyond the control of the economic development office.

One factor the development agency can control is attitude. Like a smile, it costs nothing but can close the sale. An eager attitude won International Data Systems for San Diego while an offhand air did not attract ETA Systems from Minnesota to Elsewhere.

Says Lloyd M. Thorndyke, president and chief executive officer of ETA, recently spun off from Control

Data to develop super computers: "They took the attitude that if we wanted to locate there it was OK with them, but they didn't bust themselves for us."

"The key factor in our decision," says Harold Georgens, founder of International Data Systems, "was the willingness of the community in San Diego to help, not with material incentives -- there were none -- but the degree to which the San Diego economic development people worked with us on plant site location."

In North Carolina, Edward Moore of Wilmore Electronics Company has benefitted from the infrastructure generated by the Research Triangle. A native of western Virginia, where he obtained his bachelor's in electrical engineering from Virginia Tech, Moore went to North Carolina's Duke University for his doctorate. Duke is one of the Research Triangle universities. There in 1964 a group of professors and graduate students conceived the idea for a company to manufacture power supplies for computer systems.

"It was really the university situation that got things started," said Dr. Moore, who has a high regard for the importance of universities in seeding advanced technology industry. "Lots of high-technology companies are started by people not too long out of school," he observes.

The Research Triangle per se has had little meaning for the small electronics company. But its presence has proved increasingly important in many ways. "Without the Research Triangle," says Dr. Moore, "we would not have the airline connections. It has created a pool of trained and skilled technical people. We don't have to educate local suppliers to our needs."

Wilmore is where it is because it started there and has no good reason to move. "Once you put down roots, it's really agony to consider moving," says Dr. Moore. Nonetheless, the growing company has moved much of its manufacturing to another site -- Hillsboro, N.C., a few miles away "still a Research Triangle area." And it is the constant recipient of invitations from other areas. "We just finished responding to an approach from the area where I grew up," says Moore, "and I'd love to be there but there's no business reason to go there. Until you get large, it doesn't make sense to be a multi-state operation."

Federal Government R&D facilities are often cited as major resources and potential nuclei of advanced technology centers. For reasons not well understood, substantial spinoffs from the Government sector to the private economy often fail to develop or are minimal. Numerous areas, however, have moved to make their local government operations substantial technology centers.

Among these areas is Dayton, Ohio, which centers its technology development on the Wright Patterson Airforce Base complex and local universities, the Tennessee Technology Corridor centered on the Oak Ridge National Laboratory and the University of Tennessee, the Argonne National Laboratory and the Fermilab in Illinois, the Los Alamos and Sandia Laboratories in New Mexico, the Huntsville space technology complex in Alabama, the many Department of Agriculture Experimental facilities and of course the National Aeronautics and Space Administration operations in Houston, Florida, Maryland and elsewhere.

In all there are some 280 Federal laboratories, all major employers of scientific and technical personnel, developers of new technology, users of local goods and services and frequently the major conduit for the expenditure of over $50 billion annually in Federal R&D funding. Universities and private corporations operate many of these facilities.

Whether the Federal laboratories efficiently transfer Federal R&D to the private sector is a continuing argument. As one speaker at the 1984 National Governors' Conference said: "When a commercial advantage appears, the technology will transfer very rapidly. Government is better at discovering information. The private sector excels at developing it." (For a further discussion concerning government funding of private sector R&D, see "Industry in a Changing World," United Nations Industrial Development Organization, Vienna, Austria, 1984.)

Few question that a major government technology-facility is a local resource. Such a facility generally creates a ring of technically-sophisticated suppliers ready to handle the needs of new and expanding technology companies. They are the infrastructure that is so important to smooth day-to day operations.

Wilmore found the environment it needed where it was. Others have to create it. Cliff Williams runs International Sensor Systems, Inc., from a former cow pasture in Aurora, Nebraska. The company is at the very leading edge of hybrid thick-film technology, the heart of computer disk drives and solar cells. "I had some real qualms about moving here," recalls Williams, who came originally from the state, graduated from the University of Nebraska and spent most of his working life in various places with telecommunications companies and, finally, IBM.

Williams' entrepreneurial days started with a patent on which he founded a company called Transcom in Hartford, Connecticut, where he then lived. He sold Transcom. Then he studied the technologies and settled on hybrid thick-film technology. It looked like a comer, there were few people in it and one could enter the business with modest capital.

Williams planned to start up in Connecticut and had even begun negotiations with the Connecticut Development Corporation, a state agency that helps entrepreneurs bring products to market in return for part of the profits. He had a business plan and four purchase orders as he shopped for capital.

"That summer of 1972, I came out to Nebraska," says Williams. "A local banker wanted me to start the business in Aurora. I couldn't even think of it. Nobody knew the technology there. I got a call from Harold Edgerton, inventor of the stroboscope and of EG&G and a native Nebraskan. The banker had put him on to me.

"I agreed to look the state over. The main thing would be people -- the University even had never heard of thick film technology. But as I examined the area, I became impressed with the attitude of the people -- they were agressively eager to learn. So I called Harold Edgerton and said if he would be on my Board of Directors I would start the company in Aurora. He agreed and here we are."

The company raised money from 15 local investors, no venture capitalists, and had a small business administration (SBA) commitment. Williams started with a cadre of five experts hired from all over the country. The cadre is gone now and the staff is locally developed and hired. "In 1975-76, I got on the Dean of Engineering's Advisory Board at the University of Nebraska," says Williams, "so we now have three or four courses in solid state technology being taught. That ties in with our personnel needs."

Located in the southern part of Indiana, far from the industrial area of the north, Thermwood Corporation is a fine example of adaptation to changing situations. Two colleagues working for Alcoa started the company to make plastic parts for aircraft in a barn about 13 years ago. One, Kenneth Susnjara, now president, was still in college at the time.

When the price of raw materials soared, the firm looked for another line of business. "Our plastic process was unique and we had designed and built most of our own machinery," says Kenneth Susnjara, a native of South Bend and graduate of Rose-Hulman Institute of Technology in Terre Haute. "When we switched industries, we built on our experience in designing and building equipment. Robotics was a logical progression."

Thermwood is where it is and remains there because Indiana is home. "Once you have developed and are going well, you won't move," says Susnjara, "though you might have a branch." Thermwood does its R&D and marketing from Dallas while manufacturing in Dale.

As a new factor in a frontier industry, Thermwood needed to find the right people for its R&D. Thermwood took a people approach to site selection. "We used an executive search firm to determine where the people we wanted are. Their survey showed the primary areas to be Los Angeles, San Francisco and Boston. Next are Denver, Dallas, Houston, Boulder, Minneapolis/St. Paul and Philadelphia. The primary areas are too far from Indiana, so we considered only the secondary ones. Then we looked at other factors -- quality of life, cost, traffic, transportation, availability of people. In Dallas, we felt we could get right into the infrastructure."

Thermwood is firmly committed to Indiana for its manufacturing. "We're far enough advanced so that producing a quality product is important," says Ken Susnjara. "Workers in South Indiana are good and dependable and produce a good product. The work ethic in this rural area is good. If we went somewhere else, we don't know what we'd get."

Most entrepreneurs don't go somewhere just to start a business. As Sam Irwin founder of Irwin International in Ann Arbor, Michigan said: "Companies start where people are." But Cliff Williams did move back to Nebraska. And James R. Jubb, Sr., moved from St. Louis to his vacation land, Montana, where his wife's family lives.

Jubb founded Spectrum Enterprises in 1978 in Polson, near Glacier National Park. "Our basic capability is production and some development of navigation and guidance control equipment for the military," says Mr. Jubb, "though we are developing products for the consumer and medical markets."

"Electronic companies aren't really sensitive to geography. The cost of freight for electronic products is negligible and Montana has good freight service to the rest of the country and the world. We don't have substantial disadvantages. We have no trouble getting competent people from all over," Mr. Jubb told me.

Spectrum has had no trouble obtaining money. The small company has been financed almost entirely by loans from the local Security State Bank. "One advantage of starting with military programs," says Mr. Jubb, "is the immediate cash flow. Of course, everything I own is collateral."

Montana's efforts to attract and develop advanced tehnology industry have been well publicized and strongly pushed by Governor Ted Schwinden. But these programs had nothing to do with Jubb's decision to locate there. Though he has made little use of the state's incentives, Jubb gives high marks to the effort. "We could have financed part of our capital asq sets through revenue bonds," Jim Jubb told me, "but the timing was wrong. We can also get fixed interest loans through the Build Montana programs. But we eaven't done so yet."

The rural location is sufficient in most respects for the growing company, currently 35 employees, and going to 50 in a year. "We have thought about employee availability," says Jubb. "We have no difficulty at our present rate of growth. But if we suddenly needed 100 people next year, we would move a production facility to an urban area."

The common impression of an advanced technology center is one where major companies began life, then spawned new, entrepreneurial companies. Boston and San Jose are the prototypes.

Some areas, initially expansion sites for established companies, have indeed accreted enough industry and high-powered people to become themselves self-generating technology-centers. One such is Colorado, ihose high-technology history began with a Hewlett-Packard expansion from Palo Alto.

"Most of Colorado's high-tech and medical-tech industries grew up amidst a balanced economy," Governor Richard D. Lamm told me. "Since that time, the economy has shifted away from agriculture, mining and tourism toward the industries of the future. We are adapting to the changes by competing for the jobs of the future while stabilizing the basic industries that have served us so well for so long...The Colorado Advanced Technology Institute was recently established with the sole purpose of guiding Colorado's higher education establishments as support agencies for technological change."

Having established the nucleus, the state wants to keep it and help it grow. One of the offshoots is MiniScribe Corporation, a manufacturer of Winchester-technology disk drives, founded in 1980 by an alumnus of another Colorado company, Storage Technology. Founder Terry Johnson himself moved to Colorado from San Francisco, Memorex and IBM. "It was just logical to start the business where he lived," remarks Robert J. Ganter, vice president for engineering. "He converted his basement into a startup operation." But that in itself indicates the value to an area of new companies. Spin-off.

Winchester disk technology is an extraordinarily complex and competitive business, with many well-established and well-financed factors. The industry was just beginning when Johnson attended a national computer conference and saw a hole in the product lineup. "It looked like there was room for someone else," says Ganter. "You respond to the need and keep trying. That's how you make it in this business." Echoes

Thermwood's Susnjara, "Entrepreneurs don't fail. They give up."

Colorado is not the center of disk technology, which Ganter considers a benefit. "There's an advantage to being in a cow field. You don't hear all the reasons why this or that can't be done. Unlike Silicon Valley, we have excellent staff stability. And there is good infrastructure in the Front Range now with some 600 new technology companies in the area. There are all sorts of people to do circuit boards, special machining. But we still vend a lot of things in California."

While a certain distance has some advantages, the company relies on several mechanisms to keep up with its industry. "We go to California often," says Ganter. "As a public company, our investment bankers are privy to information that's useful to us. We attend trade shows and participate in major industry reports. Lots of us have been at it long enough so that we eave many friends and there is much cross-pollination. Our suppliers supply our competition. And while California is the center, the community there can be inbred. We keep current by having to compete."

California's high-technology industry is not all in the Santa Clara Valley. Much sits around Los Angeles and San Diego. A bit more of it graces San Diego because the city made a newcomer feel truly welcome.

Hal Georgens, of Long Island, New York, a graduate of Rensselaer Polytechnic Institute in Troy, N.Y., "gradually migrated westward, as vice president at Motorola in Phoenix, then Bell & Howell in Pasadena." When at Bell & Howell, Mr. Georgens decided to start his own company, International Data Systems, to make small tape drives for the computer industry. "We started in 1974 in Pasadena in rented space across the street from Bell & Howell because that's where I was," says Mr. Georgens.

At five years old, the company filled three buildings. "We would have to relocate," recalls Georgens, who is chairman, founder and chief executive officer. "We looked at Oregon, Austin, Boulder, but it didn't seem to make any sense to move that far. We drew a 100-mile radius around Pasadena, which ran from Santa Barbara to San Diego. What with one thing and another, we set up new facilities in San Diego and phased out the last of the Pasadena operations last year."

Pasadena is the site of California Institute of Technology and the Jet Propulsion Laboratory, tremendous technical resources. But International data notes no lack. "There are excellent resources in San Diego, which is doing very well in the computer science area. We are one of seven companies funding the Magnetic Recording Research Center at the University of San Diego and I am on the advisory board to that Center."

Georgens started the company with his own money and the help of friends. "In 1974, there weren't any venture capitalists -- we had to bootstrap," he says. Since then the company has had three rounds of venture financing. The initial investors still own over 50%. Venture capital has been important to the company's growth, but its local availability was not a factor in either the initial siting in Pasadena or the move to San Diego.

A spinoff of a different sort is ETA Systems of St. Paul, Minnesota. The well-endowed developer of supercomputers is a child of Control Data Corporation, spun out of the parent with staff and financing in 1983. Control Data owns 40% of the company. The product to be ready in 1986 is a 10-gigaflop computer (it can perform ten billion FLoating-point OPerations per second).

ETA Systems did not just naturally settle down next door to its parent. The company conducted a nationwide search before deciding on St. Paul. One would have to wonder a little about the total objectivity of the search since the staff, all former CDC people, lives in the area and would have had to move if the company settled elsewhere. Minnesotans are notorious for their fidelity to their home state.

"In any case," says ETA's Thorndyke, "the design would have been done here. We were looking for another manufacturing site. There are several other companies that do their design work in Minnesota and manufacture elsewhere. We looked at California. We also looked at Texas where the Micro Computer Center (MCC) went.

The MCC was initially a Minnesota initiative, with much input from Minnesota companies, including Control Data. The organization conducted a nationwide site search before finally settling on Texas. "The MCC had already done the work," says Thorndyke, "and we had that data to work with. But in the final decision, it was the relevancy of locally available technology that decided us. Control Data, Cray and Star all make big computers. Minneapolis/St. Paul is a computer center."

What does "ETA" stand for? "Nothing," says Thorndyke. "Any name remotely connected to technology or computers is already used. So we picked the first three letters of a linotype keyboard." ETAION SHRDLU.

Geographic isolation is no bar to advanced technology industry. You can't go much further and still be in the United States than Hawaii, which many people would think an unlikely place for high technology. Governor George R. Ariyoshi doesn't agree. Neither do Thomas and Lucille Moore.

"Hawaii has attributes ideal for companies and agencies seeking a base for current or expanding advanced technology," Governor Ariyoshi told me. "Its location in the middle of the North pacific permits same-day Tokyo-New York communication. The University of Hawaii's Electrical Engineering Department is considered by some to be among the nation's top ten. Most of its graduates reluctantly leave for the mainland because of the scarcity of high technology jobs in the Islands -- meaning there is available a highly qualified labor pool for new firms to tap.

"Hawaii's legislature has established a High technology Development Corporation and has also established at the University the Pacific International Center for High Technology."

The founders of Hawaii's largest advanced technology firm, Intelect Corp., didn't care about all that. Thomas and Lucille Moore, Chairman and President, lived in Hawaii and didn't want to be anywhere else. A native of New Jersey and graduate of the University of Illinois, Tom Moore had been in the telecommunications business all his life. He ran factories in Malaysia and Singapore, with Hawaii as home base. Moore, iho once was an engineer for Hawaii Telephone Company, started the present firm in 1976 on returning from Singapore after a stint with Northern Telecom. "All of a sudden we could see that it no longer mattered where you were with the microchip," he says. The company makes microprocessor-controlled voice communications 'ystems for air traffic control and air defense. "We had a modest pool of capital and didn't want to go back to the mainland."

"The location is no handicap to doing business all over the world," says Mr. Moore. "It's an advantage for marketing to the Pacific Basin. We're inside the U.S. customs barrier. People in Asia knew us and 85% of our business is international. If you stay with high technology products, you can build them anywhere. What makes the real difference is how clever are the people. We found here a hidden pool of talent.

"The state has a false image," says Moore, "of leisure and laziness, sun and sand. The reality is it's a hard-working place. People don't like to leave. We found one man with a doctorate driving a pedicab and another pumping gas. Sometimes we need a specialist. One advertisement in a mainland newspaper drew 265 replies.

"The University graduates 100 to 125 electrical engineers but there are jobs for only 25. They go to the mainland. When they come back, they've had some experience and the itch to see the world is gone. We don't hire straight from school. When you're small, you've got to have seasoned people."

Other than as a once-removed source of engineering staff, the University has not been important to the company. "The faculty saw its mission as training for Silicon Valley. But the University people are political animals and are taking a better look at where they should be going. We're coming together."

The company initially started without benefit of venture capital, but growth demands capital. "Last December we sold 20% of the company to Castle & Cook (one of Hawaii's legendary corporations). The company is building a technology park and wants Intelect as a model. They also look on us as a venture capital investment.

"One of the problems is in getting companies to move to Hawaii. Can you imagine your new MBA telling his Board 'I want to locate our new plant in Hawaii'?"

Conclusion

When routine quality control is a step beyond what rigorous scientific procedures were a few years ago, what must be the level of science needed to support and advance today's manufacturing processes? Where the people who devise quality control procedures have advanced degrees in physics, chemistry, electronics and the like, what level of people must a company have to improve the manufacturing process or devise new ones? With whom do those people wish to associate? What do they do in their spare time? How do they refresh and update their basic skills and knowledge? What serendipitous associations and contacts spark their imaginations and lead on to the breakthroughs that are the essence of innovative technology?

The best answer to those questions is community. That means all the factors taken together that appeal to, cradle, support and stimulate the creative talents of exceptionally gifted people. A great university is not essential. A good one that is of and not merely in the community certainly is.

Perhaps the distinguishing feature of a true innovative technology center is indeed a university, but not one in the usual sense. If it be true that a university is a community of scholars, then perhaps it is true that an advanced-technology center is itself a university -- a community of scholarly companies.

The usual incentives will attract to any region its fair share of manufacturers based on transplanted technology. To attract more than its share of innovative-technology companies, however, an area must foster an environment that will attract and hold the people who dream it up. It can't be done overnight, and possibly not at all artificially. No one planned the existing innovative centers.

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Appendix

Further Comments On Infrastructure

As states and localities turn to advanced technology for the jobs of today and tomorrow, many organizations prepare studies and reports. These are designed to help government and industry understand advanced technology, examine ways in which it can be attracted and nurtured, detail what has actually been done and review the effectiveness of specific programs.

One of the more prolific producers of studies has been the Joint Economic Committee of the Congress of the United Sates, under the direction of economist Dr. Robert Premus. In 1982, Dr. Premus produced a seminal paper "Location of High-Technology Firms and Regional Economic Development," which was based on a survey of 691 companies. This report ranked the factors that entrepreneurial hightechnology companies consider most important.

More recently, Dr. Premus's group has surveyed venture capital firms. This report has not yet been published.

Another important study was that published in October 1983 by the National Governors' Association. Entitled "Technology and Growth: State Initiatives in Technological Innovation," the report is based on a detailed survey of, and responses from, all fifty states. It is probably the most complete compendium of what states are actually doing to foster advanced technology industry within their borders. The report itself is narrative analysis that reaches conclusions and makes recommendations. It is accompanied by an appendix that lists state by state the various initiatives and organizations, with names and addresses.

The NGA Task Force on Technological Innovation followed the report with a discussion paper for the National Governors' Winter Meeting in Washington last February.

Following up the NGA study, the Office of Technology Assessment (OTA) of the U.S. Congress examined industrial development initiatives. In a background paper on technology, innovation, and regional economic development entitled "Encouraging High-Technology Development," OTA identified six general categories into which the hundreds of hightechnology initiatives spawned by the states and localities fall. These are:

Technology transfer -- usually focused on improving linkages between universities and industry;

Human capital -- training and education;

Entrepreneurship training and help -- including technical and management assistance, exemplified by the Minnesota Cooperation Office (See "Minnesota: Technology Wellspring," Scientific American, October 1980.

Financial capital -- tax breaks and venture capital funds;

Physical capital -- infrastructure improvements, research and science parks, best known of which is North Carolina's Research Triangle complex;

Information gathering and dissemination -- including the high-technology task forces that the most states organized recently.

The OTA study, while categorizing state initiatives, also said most are too new yet to show much result. But if one were to place all these initiatives in a single category, that one most likely would be "Infrastructure."

Dr. Premus's work, updated in another paper "Urban Growth and Technological Innovation," finds that in general high tech firms will set up where the support structure exists. As my own surveys find, that includes an array of services ranging from educated machine shops to dependable and adequate electrical power.

Indeed, the local power company is a most important part of the infrastructure, not only because it provides energy but because it is an industrial development resource in its own right. Unlike footloose high-technology companies, utility companies are tied to their service areas. They grow only when their areas develop. As industrial factors themselves, they often have a feel for the area, land availability, local custom, taxes and the like that government agencies may lack.

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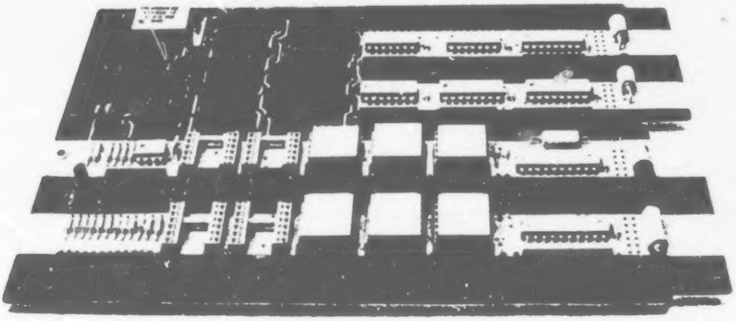
Advanced Technology Centers



Strategies for Corporate Growth

Innovation, development, and mature manufacturing at the edge of knowledge need different kinds of support.
Where to find that support is basic to corporate strategy.

Peter J. Brennan and
Development Counsellors International, Ltd.

Innovation, development, and mature manufacturing at the edge of knowledge need different kinds of support. Where to find that support is basic to corporate strategy.

It was 1938. David Packard was a young engineer, newly graduated from Stanford University, working for one of the world's largest technology firms. His employer was General Electric Company in Schenectady, New York, a pleasant and long-established industrial city a continent away from the sunny Santa Clara Valley, between the bay and the sea.

The Valley had two main exports—fruit and college graduates. At Stanford, the late Professor Frederick Emmons Terman, a tireless promoter of his students, of Stanford, of the Santa Clara Valley and of the beginnings of electronic technology embodied then in radio, fretted over the loss of his brightest students. The Professor found them jobs, too often somewhere else like Schenectady. When he could, he found financing and research contracts to keep his graduates in California, close to home.

Thus William Hewlett stayed on to do graduate work. His friend, David Packard, married to a Californian, could be persuaded to return on a fellowship. Hewlett invented an audio oscillator and Terman, himself a transplanted Midwesterner, suggested Hewlett and Packard try marketing it. In early 1939, they did, from the garage of Packard's rented house.

From Orchards to Technology

Thus did the Valley begin to change to an economy based on new technology. It was not planned. There were no consultants' studies. No one was persuaded to shut down an uneconomic plant somewhere else and move it to cheaper California. No economic development organization promoted Palo Alto to all parts of the country.

Rather, as is true for most successful advanced technology centers, a local, possibly unique, combination of people, facilities and circumstances combined to yield an unforeseen result.

Stanford had excellent electrical engineering and physics departments, poised at the edge of practical applications for electronics technology. In Fred Terman, the school and the locale had a teacher, an organizer, a man of vision and determination, a superior technologist with a firm grasp of the real world. He was the essential industry university-community linkage.

David Packard, a Coloradan, was prepared to go to the University of Colorado but "... the time I spent in Palo Alto in the summer of 1929 convinced me that I should apply to Stanford."

Like most human adventures, the process begins at a point no one then present can identify. Through a series of circumstances and serendipities, it gathers momentum. The phenomenon acquires shape, becomes large enough to have its own center of gravity. Like a black hole it begins to attract and coalesce new ingredients. A new-technology center appears amid the prune yards, on the swampy land above a salt bed, on the prairie, strung out along a highway...

Most important, the world notes that the new technology center is a net gain for both its region and the nation as a whole. Like a seed dropped on the forest floor, it has germinated, grown to maturity, gains its subsistence from roots much deeper than the surrounding shallow plants to which it gives shelter and sustenance. In time, it drops its own seeds, which grow to form a grove.

Cultivating Technology Business

We long ago learned how to farm trees so that we no longer depend on accidents of nature for timber. We can analyze after the fact what prompted a center of advanced technology to germinate and grow in the wild. We have been less successful in transplanting those conditions so that we can start and grow new technology centers wherever we want.

Technology is the key to increasing productivity of both capital and labor. A producer made most efficient by computer-aided design (CAD), state-of-the-art instrumentation and control, electronic data processing for inventory and materials management and modern telecommunications is not as vulnerable as his less technology-intensive, less efficient competitor.

Advanced technology is thus vital to the competitiveness of older industries, which will continue to exist and expand. Whether they reindustrialize in the United States or migrate entirely to other parts of the world largely depends on how well they adapt new technology to their own ends. Survival also hangs on how well the high-technology industries themselves fill the needs of their non-high-technology so-called smokestack industry customers.

State governments recognized long ago that advanced technology is the key to future prosperity. The economic vitality of Silicon Valley and the Minneapolis-St. Paul area are well known. The virtual rebirth of the Massachusetts economy based on seven high-technology industries that often started out in the abandoned factories of long-gone smokestack industries has not gone unnoticed. Neither has the symbolism. Recent economic history, however, has greatly concentrated the attention of both state governments and businesses.

Traditional regional, state or area development programs have aimed at painting an attractive picture for any kind of industry. Development officers largely were marketers rather than developers. Their sales message was and often still is financial incentives. The long-term objective was an increase in local and state tax bases and simultaneous increases in employment.

The strategy works well enough in a rising economy when addressed to traditional non-high-technology industries, whose requirements are based on the products they make, the raw materials they need and the markets they serve. However, if a rising tide raises all boats, it is equally true that a falling one exposes the rocks and impales a few of the larger vessels, which will never float again. More than any other in the past twenty years, the 1979-83 recession exposed the rocks in the American industrial economy.

High Tech Is Different

The strategy does not work as well when addressed to high technology industries. Measured against the factors that traditional industries must consider, high technology industries are virtually site-independent. They can set up just about anywhere. And they do, all too often.

Area development officers must ask: who are the Hewlett-Packards of today and what do they need?

Companies that help corporations choose sites for new facilities have started to find those answers. Robert M. Ady, executive vice president of The Fantus Company, a Chicago-based site location firm, says: "When we deal with a traditional industry, the company's short list of preferences will all be in the same region—say Texas, Oklahoma and Louisiana. But when we deal with high technology companies, the preferences will be scattered across the country—California, Texas and North Carolina.”

States, regions and localities have started to recognize this fundamental difference between high technology and traditional industries. Further, they recognize that there are differences within the high-technology industries themselves. The most technology-intensive of all industries, guided missiles and spacecraft (Standard Industrial Classification [SIC] 376) has some of the aspects of a traditional industry. At its manufacturing level, this industry deals with big items that need plenty of space. Among the largest single manufacturing facilities in the world are aircraft plants in Texas, Kansas, and coastal Washington.

Hi Tech—a Definition

According to the Bureau of Labor Statistics, a high technology manufacturing firm is one in which engineers and scientists comprise more than five percent of the total work force. That, however, is too loose a definition. It includes transportation equipment in general, for example, of which aerospace is a part, and chemicals, of which pharmaceuticals are a part.

Advanced technology industries are better defined as those that require high levels of continuing innovation and whose markets can change overnight. These firms typically have 10 percent or more scientists and engineers. Firms working at the leading edge of technology have 15 percent or more engineers and scientists on staff.

Only six industries qualify. These and their SIC codes are: Pharmaceuticals (283), Computers (357), Semiconductors (367), Communications (367), Aircraft (372), and Instruments (381 through 384).

Instruments includes medical, controlling and scientific instruments.

One must also include the service sectors that are so increasingly important in the U.S. economy. More than most manufacturing sectors, such service industries as finance, banking, communications, software development, insurance, medical services and data-processing are fast-growing users of advanced-technology products and the driving force behind the rapid commercialization of new ones. Commerce is more and more a market for industry—but commerce basically services industry.

A high-technology company typically goes through three distinct phases. Fantus's Robert Ady defines these as the theory-driven, product-driven and market-driven stages. A successful innovative and productive company will exist on all three levels. However, each phase requires a different set of circumctances at its beginning. As each phase becomes a continuing level, it requires still another set of conditions to prosper and grow.

The Three Drives

First is the initial scientific discovery and the follow-on work that converts the discovery to a commercial product. A lone and brilliant inventor, a Hewlett or an Edison, may well make the initial discovery working in his basement far from any known technology center. He may even carry the discovery to the point of commercial viability. But as the frontiers of knowledge have expanded, wresting new secrets from science and moving them up the scale to commercial practicality has become an expensive effort.

The second product-driven stage entails development and first-level manufacturing. Once a scientific idea has been proved and its practical applications divined and defined, a company will exploit it. The company may be a new one formed out of the basic research group that developed the idea, or it may be a large established one seeing opportunity in new technology.

The classical view in the United States is that small, entrepreneurial firms bring most new technologies to market. And in fact, most new jobs produced in the U.S. economy come from small companies exploiting new technologies. However, large companies with large R&D budgets and extensive facilities spend far more on R&D than do small new firms. So do universities, which, says the National Science Foundation (NSF), perform half of all basic research in the U.S.

During the product-driven stage, a company depends on its source of basic science and technology, which may be the company itself. More likely, though, the source will be a nearby university, research institute or large technology-oriented corporation from which the company's founders came. As the company expands and increases its R&D expenditures, it will become less directly dependent on external technology. Ideally, it will itself become a technology source in a growing technology center.

Outgrowing Home Base

As the growing firm's manufacturing capacity expands, its need for space and other services grows. Manufacturing remains closely linked to research and development sources. Consequently, if manufacturing and R&D cannot be at the same place, any new site must be within easy reach of the R&D center. The manufacturing site must have locally available nearly the same level of technology as does the home site. To attract and hold engineers and scientists, the new location must offer similar amenities.

Few people, not Hewlett, not Packard, not Samuel N. Irwin, deliberately move to a location specifically to found a company. “Companies start where people are,” says Mr. Irwin, founder and president of Irwin International in Ann Arbor, Michigan. The founders may be there because of a university, an employer, research foundation, government installation or were born there. Having started the firm, local factors keep the founders in the area, at least through initial success and early expansion.

Local factors may enable a newborn company to grow to a certain point in its product-driven phase. However, this stage is a critical time in a company's life. Further expansion may produce new needs that the local economy cannot fill. In its early years, any fast-growing company is locked in to its location by its need for cash to finance growth. It must generate most of that cash internally. Venture capitalists may fund a company only through startup. Equity markets want to see a track record. Conventional bankers prefer more established, less risky ventures.

When the Company Should Move

When a company outgrows the local supply of brain power, cannot attract the people it needs, encounters too much red tape in continuing financing, it moves to an area where the community understands and is prepared to serve its needs.

Or a company may outgrow its manufacturing space. Its first satellite is likely to be nearby in an area that offers most or all of the benefits of the headquarters location. Since the company can now choose its new site, management will look more closely at factors the founders could not control.

Taxes Are Important

There is a misconception that tax structure is important only to large-scale, large-employment smokestack traditional industries. To justify this view, people point to California and Massachusetts, the top advanced-technology states but far from the bottom of the list on overall tax burden.

Not so. "Taxes are very important to small, expanding high-technology companies," says Dr. Robert Premus, Dayton-born staff economist of the Subcommittee on Monetary and Fiscal Policy of the Joint Economic Committee. Premus is the author of a recent report entitled "Location of High-Technology Firms and Regional Economic Development," based on a survey of 691 companies.

"Small companies in particular rank the tax burden high," said Dr. Premus in an interview. "Cash flow is critical. Local taxes can take cash from a company when it most needs it." At the same time, they are locked into their location. By the time they can afford to move, the tax burden has become secondary. They may even move to a more heavily taxed jurisdiction.

The founder of one high-technology company explained that paradox. William C. Norris, chairman of Control Data Corporation in Minnesota, said that the State of Nebraska's willingness to increase both the tax base and rate was a powerful factor in the company's decision to locate a new facility there. "Nebraska demonstrated that it meant to provide the tangible and intangible facilities and services that (we sought)," said Norris. "Without such a change in philosophy," the Nebraska native continued, "we likely would have gone elsewhere."

The Market-Driven Facility

The third stage identified by Robert Ady is the mature manufacturing or market-driven level. The company and its products have now grown to a point where costs are paramount. The company has outgrown its older facilities. Processes and products are mature. Transportation, local financial incentives and tax structure, availability of low cost and trainable labor all assume greater importance in the site selection decision.

The market-driven firm's products are high technology. But manufacturing is essentially an assembly process. The technology and science is in the maintenance of the manufacturing systems and in quality control of raw materials and finished items. Engineers and scientists are a small percent of total employment.

This third stage plant will have different needs than the earlier stage one. This new facility is still not tied much to natural resources, nor overly dependent on market proximity. Such site-independent plants can serve markets in North America as easily from Taiwan or Malaysia as they can from Tennessee. Beyond minor input by local managers, all technology is generated elsewhere. New technology arrives daily, by telephone and computer network or encased in the latest model of manufacturing systems equipment—but it comes from somewhere else.

Such are the plants that site development managers seek. They are clean, reasonably kind to the environment. Their demands on the local infrastructure are easily met if there is adequate electrical power and water. They provide jobs for local people without placing great demands on the local services and amenities. They do not bring in large numbers of people who are accustomed to more than the community provides.

However, since these plants are essentially assembly operations, they commonly do not have the same ties to their location as does the company's technology base. To quote Dr. Robert Premus's Congressional report: "The survey ... indicate(s) that high-technology companies are 'footloose' ... access to raw materials ... markets and transportation are not major locational determinants. Nor are ... water ... energy ... and climate important determinants ... high-technology companies are drawn more to highly specialized resources such as labor skills and education and to factors that make it easier to attract and maintain a skilled labor force, most notably State and local taxes ...."

The survey also indicated that most high-technology companies prefer an urban to a rural environment. The centripetal effect of an urban-centered location brings in more people and companies and encourages technology transfer. Indeed, if a university in the traditional sense is a community of scholars, then a high-technology center may itself be a university—a community of scholarly companies.

Dynamics of High-Tech Industry

Most states historically understood little about the dynamics of high-technology industry. To attract such companies, they did little analysis and less development. In effect, the state rounded up what already existed and packaged it attractively for itinerant industry. The package did little for resident businesses and less still for nascent ones.

Miles Friedman, Executive Director of the National Association of State Development Agencies (NASDA), notes the changes in the attitudes of state development people. "It is still true that many state agencies see it as their jobs to move plants from other states to theirs. But a common business complaint is that the state agencies ignore the businesses they already have. Now there is big emphasis on in-[illegible] development and the incubation o[illegible] businesses."

Some states and localities years ago tried [illegible]velop conditions that would permit advanced technology centers to flourish. Not until 1981 did the National Governors Association (NGA) establish a Task Force on Technological Innovation. Local generation of high-technology industry is clearly an idea whose time has come.

Partially as a result of the NGA's initiative, many states from Maine to Hawaii established high-technology study groups. Eventually, some states will take all possible steps to establish and strengthen the structural elements needed to breed high-technology industry. Some few may decide that their future economies will depend on maintaining the major base of their present economies. The states' new awareness of high technology can help direct technological resources to appropriate economic sectors, whatever their place on the technology spectrum.

The Governors' Survey

In late 1982, the NGA Task Force surveyed every state governor on organization of state efforts, economic incentives, local university-industry cooperation and worker training programs. The survey report in July 1983 will have two sections. One organized by state will describe state policies and programs in technological innovation. The other, organized by program category, will make it easy to compare state approaches to particular aspects of economic development and technology by various methods.

Among the early findings: at least 11 states have appointed task forces or boards as overall policy-determining bodies on technology. These are California, Illinois, Iowa, Kansas, Michigan, Maryland, New Jersey, North Carolina, Ohio, Pennsylvania and Virginia. Most set these up in 1982, though North Carolina was way ahead of its time, having established its Board of Science and Technology, chaired by the Governor, in 1963.

Twenty-two states have advisory groups outside the state government. Their scope and linkage to the government varies greatly. Georgia, for example, recently set up the Advanced Technology Center at Georgia Institute of Technology. The Governor and legislature created the Center in 1980, but it is not a government body.

State money and private-sector matching funds finance the Maine Development Foundation, which the state legislature enabled in 1977. A governor's advisory committee proposed the cooperative business and government approach in 1975. In Minnesota, twenty-eight prominent people established last year the Minnesota Wellspring. The governor is honorary chairman. New Hampshire, which has developed a high-technology service center based on publishing and computer software around the town of Peterborough, has the Center for New Hampshire's Future. This is a private organization established in 1979.

The not-for-profit Indiana Corporation for Science and Technology was authorized by the General Assembly in 1982. The Governor appoints a 24-member board representing the private, public and educational sectors. California has the Commission on Industrial Innovation; Maryland its Governor's Advisory Council; Michigan the proposed High Technology Corporation; New York the Science and Technology Foundation, Pennsylvania the Governor's Council on Science and Technology; and South Carolina a proposed Industrial Research Board. The City of Chicago and The State of Illinois, together with Chicago universities, have created an "Illinois Technology Partnership."

The Early Starter

Few programs were as early or as ambitious as North Carolina's. As George Herbert, president of North Carolina's Research Triangle Institute describes it, the state in the mid-fifties was near the bottom in per capita income and too dependent on "old-line segments of its economy: agriculture, textiles, tobacco manufacturing, furniture and brick and tile." At the same time, the state ranked among the top ten in numbers of colleges and universities. But for their graduates there were few local opportunities.

North Carolina looked enviously at the centers in Massachusetts and California and noted that the desired industry existed in areas of strong research concentration. Further, most important research centers lived in the shadow of major graduate-level universities. The state had at least three such schools close together: Duke at Durham, the University of North Carolina at Chapel Hill, and North Carolina State University at Raleigh.

The state in 1956 decided to establish a research park in the triangle formed by the universities, thus the Research Triangle. The concept was not an instant success, nor did the founders expect it to be. As Mr. Herbert says, "They knew they were working for returns that would not be truly significant for 15, 20 or 25 years." And he cautions newcomers to the high technology stakes, "This is a reality, too often ignored by many of the groups that visit us today looking for a quick fix for 1983's economic woes."

No one really knows the optimum size and mix of the critical mass that turns a high-technology manufacturing center into a truly innovative one. Few doubt that it takes many years to reach that self-igniting concentrated mix of research centers, universities and theory-oriented industry.

The planners first established the Research Triangle Foundation to acquire land and develop the 5,700-acre park. They also set up the Research Triangle Institute in close association with the universities. None of these is a state agency.

Despite an early capture of a major industrial laboratory in 1959, others were slow to follow. By 1965, there were only nine laboratories with a total employment of 1,000. But then things began to pick up. IBM bought 400 acres. The National Institutes of Health established its National Institute of Environmental Health Sciences. Another major industrial laboratory moved in and the project was off and running.

The most recent addition is the state-sponsored Microelectronics Center of North Carolina, established in 1980. The legislature appropriated the first one million dollars for startup, and the state is providing the first 24.4 million dollars for ongoing support.

North Carolina's experience has many lessons for others. But it is not yet clear that the state has managed to produce an industrial rival to Silicon Valley or Route 128. The location is high on everyone's short list when looking at possible new locations. The universities and RTI itself are well-reputed basic research centers. But the bubbling ferment of entrepreneurial activity that is the true mark of a self-generating advanced-technology center is not yet evident.

A Downtown Research Park

Another research center started on a different premise but at about the same time is the University City Science Center in Philadelphia, Pa. There, the University of Pennsylvania and Drexel University were situated in deteriorating neighborhoods. The universities, business and community conceived The Science Center as a way to improve the city's technology base and reverse urban blight. Under the auspices of some 28 member institutions that own it, the Center began in 1964 in a renovated building. It is now an urban research center covering some 19 acres with over seventy science-based organizations in its nine buildings. Some of these organizations are new to the city while, more important, the Center encourages others to remain there.

The University City Science Center is so far the nation's only downtown research park, though Detroit and Wayne State University in Michigan are starting a similar concept in the Detroit-based Metropolitan Center for High Technology.

The University City Science Center has a relatively small Research Institutes Division. The Research Triangle Institute is a much larger, free-standing organization similar to such older institutions as Battelle Memorial Institute at Columbus, Ohio; Stanford Research Institute in Menlo Park, Calif.; Midwest Research Institute in Kansas

City, Kansas, IITRI in Chicago, Southwest Research Institute in San Antonio, Texas, and many more.

For smaller companies and even larger ones faced with scientific questions that they have neither time nor staff to handle themselves, the research institutes are an important resource. As do most companies, the research institutes often specialize in technologies that reflect their geographical location and the interests of their major clients.

Subdivisions for Technology

Clean high-technology industry usually does not need large and heavy installations. One can develop industrial parks for such industry just as one develops residential sub-divisions for people. A well laid out industrial or research park with room for expansion can be an important factor in site selection, particularly for a smaller, high-technology company making its first move out of its basement.

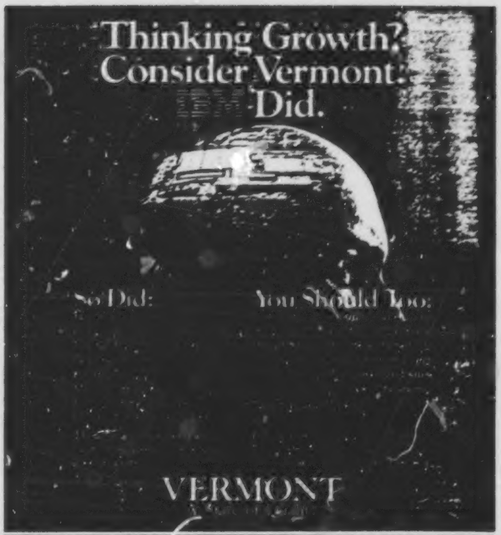
Successful developers present a balanced facility. If the park itself does not contain a research institute and university campuses, these will be within easy reach. The park will also have conference facilities, hotels, shopping centers and restaurants. A large development may be a completely planned community.

The Huron Center near Ann Arbor, Mich., is such a real estate development. A joint venture between Mitsubishi and Morgan Stanley, the Center is a 793-acre multi-use development eight miles from the University of Michigan and 25 miles from Detroit. When completed, it will contain residences as well as research labs, hotels as well as light industrial plants.

Utah, recently in the news for the artificial heart work at the University of Utah Medical Center, has a growing advanced-technology center in what one publicist refers to as "Bionic Valley," near Salt Lake City.

Montgomery County, Maryland, capitalizes on the nearby concentration of Government medical research facilities embodied in the National Institutes of Health, Bethesda Naval Hospital and many medically-oriented companies in the area. The county has established the 232-acre Shady Grove Medical Park, which has reserved 145 acres for medical science-related businesses and institutions.

Also in Montgomery County is the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planned city of Columbia with both residences and work places for people in high technology. Columbia mirrors to some extent the planned city of Reston across the river in Fairfax County, Virginia, another site for much high-technology industry.

The Planned City

An ambitious development that has learned much from Columbia, Reston and the Research Triangle is The Woodlands near Houston, Texas. This project of the Mitchell Energy Company is a wholly integrated 25,000-acre residential, research and light manufacturing community. The developers intend that everyone who works in the Woodlands can afford to live there. Several thousand people already do. In that, the community differs little from the traditional concept of the small, self-contained town, which it is.

The research forest has four elements. There will be a 400-acre campus for the University of Houston. The Texas Medical Center Inc., has 150 acres for a research campus. One hundred acres belong to the Houston Area Research Center (HARC), a research institute under the auspices of Texas A&M, Rice University and the University of Houston. Some 1,300 acres are set aside for high-technology businesses and their suppliers.

While developers take pristine land and turn it into parks, in many parts of the country suitable sites lie fallow. These are deactivated military bases. Though these sites are frequently off the beaten path, companies can turn their existing infrastructure to commercial use at low cost. Many were air bases. In Chippewa County, Michigan, for example, market-driven firms can set up on 41 acres of lighted concrete.

Other states and regions hope to use what they already have to generate new technology industry. Illinois, for example, has the Argonne National Laboratory, Fermilab, the Illinois Institute of Technology Research Institute (IITRI), the many fine universities around Chicago and the University of Illinois at Champaign-Urbana. A technology corridor extends westward from Chicago toward Fermilab. The area has an enormous base in existing medical and electronics technology. It has some of the more active and venturesome venture capitalists. But it has lacked the university-industry-community links that have been so important to theory-based entrepreneurial activity elsewhere, which explains recent Task Force development of significant education-based local cooperation.

The GOCO Connection

Many localities with government high-technology installations now see that these facilities are part of the community's technology base. They employ thousands of scientists and engineers as well as equipment and instrumentation that only the wealthiest of industries and few universities can afford. These are the GOCO (Government-Owned, Contractor-Operated) facilities. Much of their technology is in the public domain.

A government high-technology facility linked to local universities creates a high-technology center all its own. With proper encouragement, availability of capital, extended relationships with local businesses, GOCOs become a factor that expanding high technology companies must consider as well, as potent centers for local development.

Tennessee, recognizing the enormous science and technology base at the Union Carbide-operated Oak Ridge National Laboratory and the University of Tennessee a few miles west at Knoxville, has undertaken a major program to develop a technology corridor. Tennessee is not widely thought of as a high-technology area. Yet there are over 2,000 Ph. D. level professionals in the Oak Ridge area alone, including the largest concentration of doctorate-level biologists in the world.

Similar GOCOs and even GOGOs (Government-Owned, Government-Operated) facilities across the country provide ready-made advanced technology centers to which aspiring companies might well attach themselves or from which new ones might spring. Dayton, Ohio, for example, rightly considers Wright Patterson Air Force Base, the Air Force's major technical center, to be a community high technology resource.

The benefits to California of such GOCOs as the Jet Propulsion Laboratory and the Livermore Laboratory are substantial. Florida's technology has gained from the space flight operations at Cape Canaveral and the industries that have sprung up to serve them.

NASA's contribution to the technology base in Houston is incalculable. Joseph P. Loftus, Director of Technical Planning at NASA, Houston, recalls the moon-shot days when thousands of eager engineers and scientists flocked to Houston to be at the leading edge of something exciting. "I see 15,000 engineers and scientists who once worked here and stayed. They have effected an enormous transfer of material and management technology from the very leading edge where NASA works into the everyday business of the region."

New Mexico has university-operated Los Alamos National Laboratory and AT&T-run Sandia National Laboratory. These and other GOCO facilities of the Department of Energy work in many economically significant areas such as geothermal research, synfuel, solar and new and renewable energy, as well as nuclear fission and fusion.

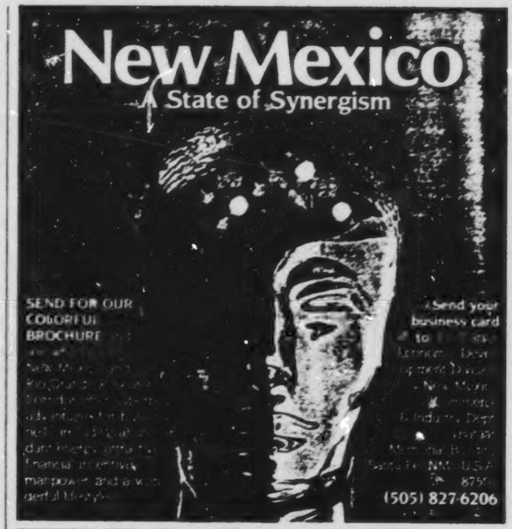
The Federal government's primary laboratory for western coal and lignite research is at Grand Forks, North Dakota. It is now owned by its former contract operator, the 100-year-old University of North Dakota, and renamed the University of North Dakota Energy Research Center. It will continue to handle government projects but will also conduct programs for other sponsors. The Center could be the nucleus of a technology center.

University-Industry Linkages

Successful technology transfer from research to commerce generally results from good linkages between the universities and industry. Such linkages do not always exist. In maintaining something of an ivory tower attitude toward the real world, some universities have forbidden their faculties to engage in commerce. But as manufacturing technology approaches levels of science once found only in the academic research laboratory, and as only industry and government can afford the equipment needed to probe the outer reaches of knowledge, more universities participate in the marketplace.

At the first meeting of the NGA task force, Dr. George A. Keyworth, Science and Technology Adviser to the President, remarked about the problem: "The resistance of the flow of technology from our research laboratories to the marketplace is abysmal," he said.

"There was a decoupling of universities and the business community," says Robert Premus. "The universities sought Federal money for their programs, which were for Federal purposes. That reduced the flow of technology into U.S. industry. But the government cut back support to universities. We see the universities getting anxious and talking to the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corporate community again."

A respected university has value to an expanding firm, because it supplies a talented labor pool, is an educational and technology resource for the company's staff, and because it attracts a continuing flow of talent. Indeed, basic to technology transfer is the flow from other university-centered areas of people who like birds carry seeds of technology sown elsewhere.

Many people recognize the problem of attracting development support from academia and are doing something about it. Solutions range from organized industry-university linkage organizations through business incubation programs at universities to loosening the rules so that faculty may more easily talk to business.

The University of Wisconsin at Madison has had the University-Industry Research Program (UIR) since 1966. UIR helps develop relationships between UW faculty and industry and helps industry and faculty identify programs, facilities and people with mutual research interests.

The Oregon Graduate Center, a non-university degree granting organization, performs a similar function. The Center has been an important factor in the state's success in attracting spinoff advanced technology companies.

In Pennsylvania, the aptly named Ben Franklin Partnership program concentrates on patents. College and university patent policies cover new developments through the advanced technology centers. Policies concern licensing in the state, royalties and other fees to support advanced technology centers.

Incubating New Businesses

At Carnegie Mellon University in Pittsburgh, Prof. Dwight M. Baumann has been trying a somewhat different approach—the incubator. He set up the Center for Entrepreneurial Development at Carnegie Mellon in 1971. Since a common feature of successful advanced technology centers is a growing cluster of entrepreneurial companies passing on through several generations, Prof. Baumann wanted "to see if we could create a cluster."

Prof. Baumann's Pittsburgh Center has been responsible for 16 first-generation high-technology companies and 9 second-generation ones. One sold for $6 million. Prof. Baumann acknowledges the importance of venture capital, but not necessarily where the entrepreneur is. "Venture capital follows innovation—not precedes it," he points out.

Where The Money Is

Most states recognize that venture capital and follow-on financing are important. Some have innovative programs to channel funds to new companies. Connecticut has a unique concept in the Connecticut Product Development Corporation (CPDC). This publicly-funded, state-chartered corporation's mandate is to invest in innovative new products. CPDC borrows from the state to share the costs of development with the company. CPDC earns royalties and repays the state treasury. The funding is not a loan, but neither is it equity. On a successful product, CPDC can recoup five times the development funding. If the product fails, CPDC loses its money, so far about 3 percent of its total investment.

Michigan has begun to move into areas where private capital has been absent. The state has venture capitalists, notably Doan Resources of Midland, but they are not sufficient to the demand. So the state legislature passed new laws that allow state retirement funds to make equity investments in Michigan businesses. Over $350 million is thus available to high technology companies.

Under new legislation proposed by Governor Ted Schwinden, Montana will invest 25 percent of certain tax proceeds in new and expanding Montana firms, about 13 million dollars the first year. Some 20 percent of the state's own investment portfolio will be in new or expanding Montana firms, about 140 million dollars per year. The state will also create a private-sector venture-capital Montana Development Credit Corporation.

Maryland takes a somewhat more conventional approach. The Development Credit Corporation of Maryland (DOCM) does not take an equity position, rather it lends money to fledgling firms that have shown some evidence of managerial ability to operate at a profit.

Different States, Different Styles

As the competition to attract advanced-technology industry intensifies among advanced technology centers, the states and regions have begun to resemble the firms they seek. Economic development departments are becoming analogous to profit centers. They raise money, mount marketing efforts, devote more attention to such quality controls as cutting out bureaucratic red tape and honestly analyzing themselves to isolate specific benefits and competitive advantages.

The mode and philosophy of economic development varies greatly from state to state, as the NGA survey makes clear. The governor himself, however, is the chief economic development officer. States Fantus's Robert Ady "The Governor is the ultimate spokesman. He makes a profound impression by his personal involvement in the economic development process."

Some states maintain a relatively low-key, low-budget effort. There may be a small office buried in another department or attached to the Office of the Governor. Cities and counties may have only the business-funded local chamber of commerce.

Others rival many countries. A well-funded central organization may have a cabinet-level director and control of a huge budget for everything from advertising to financial aid. Such an organization may well have branch offices in other states and in foreign countries.

Some states that believe they have a special focus maintain relatively small organizations. Delaware, for instance, seeks high-technology industry but is more oriented toward technology-using service industries like banking and finance, a route North Dakota has also taken. Delaware is one of only four states with a court devoted entirely to business law, the Court of Chancery. Other states, says Delaware, can change their systems to match. But nothing can match Delaware's eighty-year history of case law in business affairs.

A few states have publicly-funded municipal and county development organizations that are nearly as prominent or more so than the state organization. A gain for the county or city is of course a gain for the state. But once a county or city organization learns of a prospect, the rivalry and competition can be as fierce as any between nations.

Utilities Eager to Help

Companies need adequate and dependable utilities. Among the factors that influenced the government's decision to install Fermilab's huge particle accelerator in Illinois, for example, was Commonwealth Edison's ability to satisfy enormous instantaneous power demands at a reasonable price.

Dependable power is seldom a problem in the United States. In any case, utilities are not a deciding factor for most high-technology companies. However, in many states the utility companies are a valuable resource in another way. They are literally wired in to their state or region. As investor-owned companies, they are invaluable information sources.

Sometimes the utilities do more state promotion than the states. As John H. Maddocks, General Manager for Area Development at New Jersey's Public Service Electric and Gas Company puts it: "We're part of New Jersey. The vitality of our company is related to the economy of the state."

Michigan's Consumers Power Company gives prospective Michiganders extensive information. Not only does the company help select a site, its training program for Michigan communities shows them how to retain industry and attract new ones.

A new company or an expanding one thus has many places to turn in seeking those factors that will best suit its unique needs. Company management, particularly when looking for new sites for market-oriented plants, cannot easily rule out any location. It is a truism that every place will uniquely match someone's needs. And, to quote Florida's promotional motto, "People like to work where they like to live."

Venture Capital—High-Tech Nutrient

Most government financial incentives have little to do with getting the shaky embryonic firm with a great idea out of the basement, garage or university laboratory and into the marketplace. That function is truly the province of venture capital. A few states have made some provision to help guide state funds into venture funding. But it is not yet clear what form these initiatives will eventually take.

They might be repaid out of profits to an extent beyond the initial sum. Such a form, similar to that of the Connecticut Product Development Corporation, is a grant whose reimbursement is contingent on the success of the enterprise. Maximum reimbursement is limited to five times the

General Instrument Microelectronics, New York, investing $17 million to double the size of their micro-chip fabrication plant.

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Venture capital is equity money invested in the early stages of a company's life to help it grow beyond startup. While the initial money will have come from principals and their families, venture capital generally comes from outsiders, who take shares in the company and will become part owners.

Relations between venture capitalists and company founders are complex. They can be difficult depending on how much control the venture capitalist demands and the founder is willing to yield. (For an excellent discussion on this point, see "Raising Venture Capital: An Entrepreneur's Guidebook," published by the New York accounting firm Deloitte Haskin & Sells.)

In the Last Analysis

A management's decision on where to put the new high-technology manufacturing plant can rest on intangibles. Among the factors Bob Premus's survey found was the company founder's place of birth. As says Colorado-born David Packard, "I have always had a high regard for the University of Colorado and it may have something to do with my interest in our location in that part of the country."

Hewlett-Packard's first expansion beyond Palo Alto was to Colorado.

Managements want to increase profits. Mature managers will consciously examine every facet of their company's position within its own evolving industry and the company's own stage of development. Those in the theory-driven phase may also make all the right moves more out of instinct than reasoned strategy—one reason so many company founders find themselves ousted as the company enters the product- and market-driven phases.

But instinctive or planned, any high technology firm must encounter, consider and deal with these many factors governing the right location at the right time in the company's history. No advanced technology business in today's fast-changing markets can stand entirely alone.

A U.S.-based high technology company in the theory- or product-driven stage would not usually locate its operations overseas. There are exceptions, especially in bio-medical technology. An overseas location can allow such a company to bring a product to market sooner under perhaps more relaxed regulatory procedures than those in the U.S.

When a high-technology product reaches the market-driven commodity stage, however, and costs and market access outweigh most other factors, management must look as closely at overseas sites as domestic ones. A company will usually consider off-shore manufacturing if it also has or expects to develop markets abroad. However, foreign production occasionally makes economic sense even when all output goes to the U.S. market.

Many countries are eager to attract high-technology manufacturers. Countries want these industries for the same reasons the states and localities of the U.S. do. They provide jobs, help upgrade local skills and eventually increase the tax base. More important in the view of many countries is the potential for technology transfer. Sadly, the latter expectation is usually a vain one unless a country already has a strong technology base of its own.

That has not deterred most of the world's nations from competing for high-technology industry. Just as have the several states, many have set up special economic development agencies designed to bypass much government red tape and deal directly and efficiently with high-technology companies. Some of these such as the Northern Ireland Industrial Development Organization (NIIDO) are virtually autonomous and empowered to deal with new companies on a range of issues far beyond those that most domestic development agencies can handle on their own authority.

Overseas organizations like NIIDO offer as incentives the same range of financial and personnel benefits as do the U.S. organizations. And as do the U.S. states, other development agencies such as the Industrial Development Authority of Ireland (IDA), the French, German, Italian, Danish, Luxembourg, Malaysian, Singapore, Sri Lankan and more will try to match those incentives. Indeed, as agents of sovereign governments, not governmental units, these overseas organizations can compete at an awesome level, one few states could match.

Though location per se is seldom the primary factor for a market-driven facility, it can be important if the market is an export one and the company has extensive overseas interests.

Northern Ireland gives ready access to the European market and particularly to the British and British-dependent markets from within the political boundaries of the United Kingdom. Ireland is an English-speaking jumping off place for all Europe from within the Common Market. Luxembourg is a money center. Austria is the gateway to Central and Eastern Europe and Hungary is the stepping stone.

Caribbean dependencies of European countries, such as the Netherlands Antilles, allow favored access to the Common Market from bases closer to home. Special agreements allow other countries like Trinidad and Tobago such access too. Puerto Rico and the U.S. Virgin Islands confer tax benefits no state can match. A high-technology firm can serve markets in Asia better from Sri Lanka or Malaysia.

Most nations have active investment-promotion programs. In some, as in many U.S. states, local units such as Glenrothes in Scotland work in parallel with the national agencies. As in the states, the degree of skill, resources and commitment each nation brings to its promotion effort varies enormously.

Profit is no longer a dirty word in many countries. Foreign investment, once shunned, is now sought. But old attitudes die hard. As one skeptical participant in a recent investment promotion conference said: "Politicians propose; bureaucrats dispose. What have you done about your bureaucrats?" The more successful organizations like NIIDO and IDA were designed to shortcut bureaucratic channels. For lack of that authority, some nations' efforts remain hobbled despite the best intentions.

Numerous investment promotion agencies have branches in the United States. Reflecting their independence, these are not connected to embassies or consulates. Other nations treat development as a sideline for diplomatic personnel.

At the urging of a staff member, Adly abd el Meguid of Egypt, the United Nations Industrial Development Organization (UNIDO) in 1978 set up a program to help governments develop their own investment promotion capacity. The U.S. Overseas Private Investment Corporation (OPIC) helped fund the project. Several countries run their promotion efforts out of UNIDO in New York. Sri Lanka was one of the first and more successful graduates of that program. The country's success reflects location and commitment.

Representative **Lungren**. Thank you very much.

Again, I thank you both for your testimony and the quality of the preparation.

Let me just ask a general question of both of you for your comments.

We've had regions of this country known as the smokestack regions that were predominant for some period of time, and we now have the Sunbelt that some refer to, talking about the nature of the businesses in some cases, talking about the weather in other cases.

Is high tech and a high-tech strategy or high tech as a dominant element of the industrial mix possible for every State or region in the country?

How do you define high tech in that sense, and are there opportunities outside the Nation's generally accepted three high tech complexes: Silicon Valley, Route 128, and the Research Triangle Park? I don't mean to be overly cynical about this, but are we suggesting, in some ways by our emphasis on high tech, a goal that is not appropriate for certain parts of the country?

Mr. **Beilman**. Let me comment by saying that it depends on the individual State. North Carolina is a heavy manufacturing State, and most new manufacturing jobs, about 75 percent, are coming from the so-called high technology areas. Mr. Brennan has defined those in terms of SIC codes, and I believe that the committee has as well. If you are going to replace those jobs, then, of course, high technology is the only logical place to go to get it. You can't replace it with services. We are already a 70-percent service economy nationally, and to suggest our balance of payments, we're going to have to put more emphasis on manufacturing. And manufacturing growth is coming primarily from advanced or modern technologies.

And so, it is a fundamental strategic need to identify and pursue these new technologies and develop the innovative environment, as it is being done in North Carolina.

I don't believe that there is a risk of too much of this activity. Change is an evolutionary process and all of these State efforts are going to help cultivate the environment for the technological change which is inevitable.

The question of Route 128 and Silicon Valley, I think, has some very interesting aspects to it, and I know you are going to have some hearings in those areas, but I would suggest to you, you might want to examine the influence of Federal spending in those areas.

Silicon Valley did not result just from the fact that Bill Hewlett found he could build an oscilloscope in his garage. There were enormous Federal investments over a period of time in Silicon Valley and Boston. As was pointed out in one of Mr. Brennan's articles there were Federal investments of $66 billion in semiconductor research alone in the 5 years from 1955 to 1961, much of it for the benefit of those two areas. That is, by the way, a national industrial policy at least in part. And I think if you look at the Federal expenditures in R&D you'll find that they had a substantial influence on what has happened in Silicon Valley and around Route 128. The Research Triangle Park does not have any significant defense industry. The park has just developed as a result of the long-term investment that's been taking place there.

Mr. **Brennan**. I think it is unfortunate in a way that so much of the high-tech phenomenon has been so directed to the Silicon Valley. The Santa Clara Valley phenomenon centered on Stanford University, I think, is unique. It differs even from that in the Route 128 Boston area. Massachusetts is still very diverse as is all of New England. It is still a very diverse economy, but you'd be hard put to find much besides electronics and communications and high technology industry, other than a few surviving plum yards, between San Jose and Palo Alto. And when all of these other areas start looking to be high technology centers, they want to model themselves after that area. But there is an enormous market for the technology.

Sometimes I think people lose sight of the fact that the technology is not an end in itself. It exists and is developed to increase productivity, to increase standards of living, to make existing industries more efficient. And that technology is being invested in the automotive industry and in the steel industry. I understand now that the smokestack States are beginning to turn around somewhat, not to what they were, but because they are bringing this technology in. Michigan and Illinois and similar States have been making tremendous efforts to bring this technology into their own manufacturing processes. We have to look at what the ends are, before we start talking about building little Silicon Valleys all over the country. We don't need them that much.

Representative **Lungren**. I think you make a good point about the smokestack industries, if, in fact, we are going to maintain them, or at least make sure that they are not completely wiped out, we have to apply high tech to those industries. And so you don't necessary have a tremendous conflict between those two concerns. You have a complementary effect. In fact, a necessary effect, if smokestack industries are going to participate in the future at all.

Let me ask you this question, perhaps I'll get a little different observations from the two of you.

North Carolina, it's accepted, has excellent, great universities. And you have the Triangle down there that is well-known, in terms of its ability and its product of technology, yet there has not been—and you can correct me if I'm wrong—but as I understand it, in my observation, it suggests there has not been much to suggest in the spinoff of many small innovative companies to date.

Mr. Brennan, you noted that entrepreneurs can develop in areas without great research centers or universities. You suggested all you need perhaps is good ones. In some cases, if you have the people with you, you may not even need that, at least at the very beginning.

What does that say about State and local activities? Does it suggest that perhaps we ought not to overstate the necessity of the great universities, in order to support high-tech industries, particularly spinoff industries? Does it suggest that those spinoff industries may take place in areas that we can't even anticipate now, because of perhaps—in some ways, the very eccentric reasons, perhaps, why a company might start up at one place or another?

Mr. **Brennan**. I don't think that you should draw too large a generality from these few examples. Research Triangle is a very important development in North Carolina, but it has, in fact, taken—what, 25 years?

Mr. **Beilman**. Yes, just about 25 years.

Mr. **Brennan**. About 25 years to get to the point where it is more than an attracter of large companies that want to set up research institutions and research organizations, based on the educational infrastructure there.

One of the things I only touched on here—I'm talking about the one company I talked to in North Carolina, which applies elsewhere too—is the infrastructure that organizations like the Research Triangle, like the Route 128 area, like the Minneapolis-St. Paul area, do provide to companies a support structure that any business needs, from specialized machine shops to overnight development of printed circuit boards. I really have to question whether or not people near Glacier National Park or out in western Nebraska will find that support nearby.

Despite the excellent transportation that you have to practically anywhere, I have to wonder whether the fellow out in Montana can get what he wants immediately, or if he has to wait 3 or 4 days or maybe 1 week or 1 month to get the things that he needs. People who have set up companies in a developed center have access to all that support.

Mr. **Beilman**. North Carolina does have a lesser amount of these new entrepreneurial developments taking place. There are cultural kinds of factors involved. For example North Carolina has been a relatively poor State and has been highly agricultural even though there are large manufacturing areas and a large manufacturing work force.

Also, the universities have not had intellectual property rights provisions that were very attractive. There has been 15 percent participation on the part of inventor and that has just recently been changed to 25-percent gross participation.

Financial incentives are very important to the entrepreneur and we expect, through a new task force on innovation to see a great deal more entrepreneurial activity. But the entrepreneurial spirit is cultural and you do need a supporting infrastructure. I would put North Carolina in a kind of a takeoff phase. Those phases can also be developed in other places where there are good universities and where there is not already the kind of proliferation of new businesses as exists in Silicon Valley or Route 128.

Representative **Lungren**. How important are these incubator facilities in encouraging the entrepreneur? Obviously we have a finite number of them, and are they as important as we like to believe they are? Because, obviously, some get in and some do not. Is there an appreciable increase in the number of businesses that are generated and then actually developed through the use of incubator facilities?

What I'm trying to get at is this. Often times in our Government we say, OK, we established this program and here are our successes. But we never look at what would develop without the program. We never look at what would have developed if that capital wasn't used in that endeavor and instead was used in a program somewhere else.

What are the unique characteristics of the incubator facilities that lead you to believe, Mr. Beilman, that this will help in North Carolina being successful in the spinoff companies that we've talked about?

Mr. BEILMAN. Well, I think the incubator approach is extremely important. There are certain levels of creativity that exist that do need special support, in a technical sense, for marketing or manufacturing or finance or just management in general. The incubator facility provides that. However, if you triple the incubator facilities you're not going to triple the number of successes. I think there's a certain level of incubator effort needed to accommodate those good ideas that are coming along. I also think that there will be an exponential number of new good ideas as people get more confidence and more role models in developing areas.

So, I think there's a necessary level of incubator capability but I don't believe that is the solution to the problem. If you look at attracting industry, and much of industry is new industry that comes from existing companies that need a new location, the amount of jobs you can bring into an area like Nroth Carolina by attracting major corporations far exceeds in the short term, the number of jobs you can get through incubator facilities or new entrepreneurial activities. But in the long term, of course, those activities become very important as this exponential factor takes hold.

Representative LUNGREN. Mr. Brennan, would you have a comment on that?

Mr. BRENNAN. I don't know that much about the incubator facilities. I know that there is one that works very well out at Carnegie Mellon, at Carnegie University in Pittsburgh. That was developed out of an MIT program, if I remember correctly. Also, there are some around Minneapolis-St. Paul that are based on the university there and the Minneapolis programs, or the Minnesota programs that are very entrepreneur intensive.

But you have to make a distinction here. We're talking about attracting new industry. Between pirating industry from an area and legitimately attracting the expansions of companies that are setting up, just growing. I think that all the States can legitimately compete to attract a new IBM facility or a new general electric facility or whatever the case may be.

I think that an organization like the Research Triangle is in a very strong position to attract that type of industry that is more than merely assembly, which can go anywhere. As Bob Premus has put it, foot loose. But that requires a very high level of technology input and that's not pirating jobs. That's generating new jobs. I think this is where organizations like Research Triangle become particularly important.

And the other thing I think is that it is a generational thing. The single most important thing I think for developing new industry is a good university, as I said in my remarks, that is in and of the community. That actively interacts with the enterpreneurs in the neighborhood and with government officials and the private enterprise in the neighborhood

If you have that kind of a university then I think you can get the people who graduate to stay in the neighborhood and not go to another State. It was said to me at the University of Illinois, for example, that they were training people for Silicon Valley. Same thing said about the University of Hawaii. They graduate 125 electrical engineers a year. There are only jobs for 25 of them. As Mr. Moore said to me, the staff or the faculty at the university looks upon its mission as a training ground for Silicon Valley. Well, that doesn't do Hawaii any good.

I think the educational system from the ground on up is the key.

Representative LUNGREN. Mr. Beilman, you indicate in your testimony, generally speaking, what the North Carolina Microelectronics Center is, but could you be more precise as to its mission and how it is utilized in this important area of technology transfer?

Mr. BEILMAN. Yes; it is a consortium of the five universities, plus the Research Triangle Institute. It's a nonprofit company and has a board of directors which includes the chancellors of all the universities.

It is designed to support the universities. That is it's primary role. We are funded by the Department of Commerce not from educational funds and it, therefore, represents incremental support for universities. It's job is to assemble the kind of talent that's necessary to address the next generation of integrated circuits. That submicron generation which our international competitors see as the key to economic success in a whole range of industries. We've targeted that technology because of its unique scientific content. That is, it will be more like pure science on the manufacturing floor.

Putting 10 million transistors on an integrated circuit and getting productive yields, and quality, is a unique scientific challenge. Rather than having the universities directly develop production technology, which is not their role, we act as an interface between the universities and industry. The university people work with our staff in the building doing basic research and industry works with us, identifying what their requirements are. All working together in the same high technology integrated circuit facility in order to get this technology transferred. Technology transfer takes place through people working together not through reports.

And, so, our role is to enhance the ability of the universities to do research and to attract more people to the university. We've brought in over 30 people from industry, to the universities, reversing the traditional flow to support the almost crisis proportions of faculty vacancies in that field. We also provide a centralized investment for the universities. Our $30 million facility is essential for doing first class work in the universities but a single university cannot afford that kind of an investment and the upkeep associated with it, so we provide capital concentration and thus capital leverage for them.

The other thing we do is to help leverage human resources. We're putting in a $6.5 million two-way dynamic color television system so that, for example, a faculty individual at North Carolina State can teach live, simultaneously at all five institutions and have interactive associations with the students. There aren't enough faculty to go around to fill all of the vacancies and so one of our roles is to leverage, human resources, as well as capital resources, and to provide a unique mechanism, a neutral laboratory that will preserve the university and address the industry requirement for technology transfer in this uniquely difficult field.

Representative **Lungren**. In your relationship with industry are you predominantly working with large companies or is there a mix with small companies as well?

Mr. **Beilman**. Yes, we have different levels of association. Many large companies are working with us or considering working with us. But we also have affiliation with smaller companies and we also have a unique relationship with North Carolina companies because of the fact that our funding, almost $50 million to date, comes from general revenue sources. If entrepreneurs see an integrated circuit need, they can come to us and we'll provide some technology selection guidance, let them use our integrated circuit design system and we'll fabricate prototype quantities for them.

So, we have a relationship with large companies, intermediate and small companies in North Carolina.

Mr. **Brennan**. What's your relationship to the microcomputer center in Austin?

Mr. **Beilman**. The MCC does not have this semiconductor research capability but I believe there are two new joint development companies with objectives similar to ours, being considered by large companies. One is named after the VHSIC program and the other is called the Leapfrog Program with the objective to develop the next generation of semiconductor processes. But currently we're the only people who have a facility and program in that area.

Mr. **Brennan**. I see.

Representative **Lungren**. Let me ask this—both of you—from your perspectives. Do you believe the Federal program, such as the small business innovation research program requiring a certain percentage set aside from Federal agencies' R&D budget for small business, has been helpful to State and regional development efforts in the high-tech area and have the States done enough in working with this program to integrate it with the other things that they are doing or wish to do to attract, maintain and expand their high tech base?

Mr. **Beilman**. Well, as you know, that program is really in its early phases. The impact should be very substantial as the budget increases and I believe that States are going to recognize the opportunity to enhance the winning probabilities of their own people. If you look at the winning ratios, they average 1 of out 10. Some States are doing better at one out of four, five, six and others doing worse at one out of much larger numbers.

I think States will recognize that it is a healthy and attractive area for getting support for small business and really could be conceived of as an extension of State SBIR programs.

Representative **Lungren**. Mr. Brennan.

Mr. **Brennan**. I have nothing further.

Representative **Lungren**. OK.

I want to thank both of you for testifying here. You've given us different perspectives as did the Governors on this question. I think many of the comments that Mr. Brennan made indicated the human, personal aspect of many of the decisions in many of the factors that go into making up decisions for the location of businesses or the relocation of businesses or the expansion of businesses.

And one of the things I'm trying to focus these hearings on to a certain extent is how we take that into considering in our observations and in our decisionmaking process.

Mr. BRENNAN. If I could modify that just one bit. I think it's important to stress when we're talking about the personal aspects of locating a business, you're really talking about the small entrepreneurial business where the decision is made by the person who started the business or a very small group of people. This doesn't really apply to the large corporation that is making a sound business decision about where to locate a new facility.

Representative LUNGREN. Well, I understand that very much. One of the things we have to realize is, however, that much of the job generation we've had in this country over the last decade has not taken place with respect to large businesses, it's taken place with respect to the small ones, the startups or the ones that have been small for a certain amount of time and now are trying to expand, but would not be considered under any stretch of the imagination as large. And obviously I'm concerned about big business and how they would do but I'm more concerned about how we encourage the small entrepreneur to develop.

And in some ways, on the Federal level, we often have generalized about all business from the experience we've had with the large established firms. Well, that's great. That tells us how the large established firms got to be established over the last 30 years, but it really doesn't tell us a whole lot about how the large established firms 30 years from now are being developed now and how we can assist in that development.

So, I appreciate your distinction there, but I think your observations are very important for us.

Mr. BRENNAN. Some of the large established firms were very small firms once. Hewlett-Packard is a particularly good example of that, in the way the company started and where it first located outside of California, which was Colorado. That is where David Packard came from.

Mr. BEILMAN. At the risk of being redundant, the most important element that I see in the small business area, in addition to all State activities and the Federal level, is the fact that all of these larger companies are having to form joint development companies to compete. The results of those developments are not going to be made available to small business until 3 years later, which could be a fatal interval for many of them. Something must be done, in my estimation, to make sure that all of these new emerging firms, the Hewlett-Packard's of the future, do have timely access to the very sophisticated kinds of technology that are being developed. Right now there's really no mechanism for such access and I think it's an area that needs some attention.

Representative LUNGREN. I appreciate it. Of course, as you know, we've just recently passed the joint R&D antitrust bill, which is to assist in allowing all companies, no matter what their size, to engage in joint research and development without the worry that they have had about running afoul of antitrust laws.

One of the first things we found when we had a hearing on it was the document that was put out by the Justice Department Antitrust Division, which was quite thick and which indicated all the things that if followed you would not find yourself running afoul of the law. However, there was a forward at the beginning which said that despite everything that was in there, it may or may not apply in your case and it did not restrict the Federal Government from going after you in an antitrust suit later on. And people wonder why that did not encourage entrepreneurs to get involved in joint research and development.

We've at least taken that step, but I think you're right, we ought to make sure that it is something which is compatible with small companies as well as large.

Again, I want to thank both of you for appearing before us. It looks like we hit it just right. We have a vote on the House floor for the first time today. Thank you.

The committee stands adjourned.

[Whereupon, at 11:30 a.m., the committee adjourned, subject to the call of the Chair.]

APPENDIX

STATEMENT OF EDWARD V. REGAN, COMPTROLLER, STATE OF NEW YORK

Mr. Chairman:

The President's Commission on Industrial Competitiveness was established in June 1983 to identify ways to increase the long-term competitiveness of U.S. industries at home and abroad. The Commission consists of 30 members from industry, universities, unions, and government. It is chaired by John Young, President and CEO of Hewlett-Packard. The Commission will complete its work in December of 1984.

The Commission is identifying recommendations in four major areas: R&D and manufacturing, human resources, capital resources, and trade. While much of the Commission focus has been on actions at the national level, I have asked as a member of the Commission to lead a special study of how state governments are promoting innovations in these areas. This study is being carried out by SRI International of Menlo Park, California, with the assistance of Chemical Bank of New York.

Today, much of the action on competitiveness issues in the United States is occurring at the state level. Our report will summarize the broad range of initiatives now under way and highlight specific innovations. It will be completed by the October 23, 1984 Commission meeting.

Based on our review of state initiatives to date, we find the range of activities in progress in the areas of technological development, human resource development, capital resources, and export trade to be impressive. The states are once again serving as the "laboratories of democracy."

In technological development, numerous efforts are under way to increase the utilization of new technologies by encouraging university-industry research arrangements. The linkages that develop can play a vital role in the revitalization of mature industries. Recent initiatives include research and development partnerships, targeted technical assistance, and technology commercialization programs. Michigan's Centers of Excellence, Indiana's Corporation for Science and Technology, and Pennsylvania's Ben Franklin Partnership are particularly noteworthy examples of state action in this area.

In human resource development, states are also taking the initiative particularly in education reform and employee training and retraining. Nearly every state has recently made some effort to improve the quality of its schools. Under the direction of Governor Hunt, North Carolina has become one of the national leaders in educational reform. Their comprehensive program includes the establishment of minimum competence exams for high schools, summer institutes for teacher retraining, and a special fellowship program to attract exceptional teachers, as well as the creation of public-private model partnership programs in eight local schools. Florida has developed an innovative master plan for its state university system, emphasizing the university's role in economic development. Michigan has become a leading state in implementing comprehensive elementary and secondary school improvement programs on a school-by-school basis. More generally, states have increasingly reexamined teacher certification and pay systems, graduation requirements, and the level of support for their univiersities. As in the field of technology development, cooperation between state governments, corporations, and universities is playing a vital role.

In the area of employment training and retraining, more effective state government/business communication has begun to encourage the growth of programs that are more sensitive to business skill needs. Many states now offer customized training on a firm-by-firm basis to new or expanding companies. Illinois' High Impact Training Services, Indiana's Training for Profit and Masschusetts' Bay State Skills Corporation are prime examples.

In the capital resources area, several states have established programs to support new product development, to encourage private sector investment in new enterprises, and to provide venture capital for fledgling companies. A leading example is Connecticut's Product Development Corporation, which is a quasi-public agency organized to provide risk capital to existing businesses for new products and procedures. The Corporation underwrites up to 60 percent of the development of new products by making direct grants to the firm. In return, the Corporation receives royalty payments from the sale of successful products. Another innovative program is Indiana's Corporation for Innovation Development (CID) which was created to provide venture capital funds to new and existing small businesses for job creation and to encourage research and development activities in the state. CID is designed to attract private investors from within the state and operation as a private corporation. Finally, in some cases, states themselves have become lending agents. For example, the State of Michigan has liberalized its public retirement funds laws, making it possible for public pension funds to invest between two percent and five percent of their portfolios as venture capital in small businesses. The funds invest in firms that have excellent growth potential, profitability, and equity appreciation.

In the export trade area, the 1982 Export Trading Company Act has encouraged the formation of state level export trading companies that address the needs of small and medium-sized businesses. One of the more innovative programs is the Port Authority Trading Company (XPORT). A bi-state, quasi-public organization operated by the Port Authority of New York and New Jersey, XPORT provides a range of services, including on-site Commerce Department assistance, available in the form of "one-stop shopping" for domestic companies. Another innovative initiative is the Minnesota Export Finance Authority (MEFA) which was created to facilitate the financing of exports by small and medium-sized businesses in the state. MEFA provides up to a 90 percent guarantee on working capital bank loans to exporters.

In addition to these areas, a special focus of the study is to identify state initiatives that encourage entrepreneurship. These efforts are extensive and diverse. They include initiatives that promote new ventures, such as Texas A&M's INVENT program (Institute for Ventures in New Technology). They also include initiatives which provide technical assistance to potential entrepreneurs, such as the Utah Innovation Center.

In addition, over 150 colleges and universities offer academically oriented entrepreneurship programs at the graduate and undergraduate level. Rutgers University offers one of the oldest such programs, while Florida A&M has broken new ground by offering a program geared toward fostering minority entrepreneurship.

Overall, these state level activities reflect new views about economic development that mark a significant departure from earlier state efforts. Whereas traditional state economic development focused primarily on attracting new industry, largely through tax breaks and public subsidies, new economic revitalization efforts have focused more on encouraging new enterprise development, retooling the workforce for new technology jobs, revitalizing mature industries, and promoting the comparative advantages of industries in the state and region. This is an imporant shift because it allows states to move away from "zero-sum games," in which one state's gain is another state's loss, to a more productive situation where all states benefit by creating new jobs and new wealth for their residents. The role of new technologies in both stimulating the growth of new enterprises and helping to revitalize traditional industries is key to these new types of state-level economic strategies.

In addition, the importance of public-private collaboration in addressing state-level issues must be emphasized. States that are succeeding in new revitalization efforts are those states that have built a strong bridge between the public and private sectors in developing new efforts in technology, human resources, capital, and exports.

Finally, our work in documenting state initiatives highlights the fact that many of they key issues in competitiveness must be implemented through a federal system. States play major roles in such areas as education and training, public university involvement in technology development, and regulation of banking practices that affect the availability of capital assistance to new and small businesses. To achieve many of the national level objectives suggested by the Commission, actions by the federal government as well as state governments will be required. For this reason, it is important to be aware of how state-level innovation can complement and augment federal action and action by the private sector in addressing key competitiveness issues.

We would be happy to provide you with any additional information on this project and we hope that you feel free to share your findings with us.

Thank you, Mr. Chairman.

STATEMENT OF WILLIAM C. NORRIS, CHAIRMAN AND CHIEF EXECUTIVE OFFICER, CONTROL DATA CORP.

I am pleased to participate in your hearing on ways to improve the climate for innovation in the United States. For more than a decade, I have been devoting a substantial amount of my time to that issue. This effort has been largely focused on expanding technological cooperation because that is the single most cost-effective way to expand innovation. Cooperation must be broad-based and must include technological cooperation among large companies; among industry, universities and government; between large and small companies; and at the community level among all sectors. In addition, states should form regional organizations to promote technological cooperation among themselves and with foreign countries. I will elaborate on each area.

LARGE COMPANIES

Beginning with large companies, it is important to emphasize that we should not only encourage increased cooperation in research, but also strive toward cooperation which is in support of competition. A properly constituted cooperative research venture represents cooperation now in support of enhanced competitive performance in the future.

Let me be more specific and turn to the myriad U.S. industries which can be characterized in at least several of the following ways:

- rapid technological advance;
- growing costs of assaulting each succeeding scientific and technological barrier to progress (the bet-your-company syndrome);
- shortage of skilled research-oriented personnel;
- insufficiency of research facilities;
- too little research to support reasonable scientific and technological progress;
- substantial and growing competition from non-U.S. firms in both U.S. and other markets;

Far more industries than you may at first recognize display at least three or four of these attributes and thus are candidates for the establishment of a cooperative research venture. It should also be noted, however, that a high degree of reliance on science and technology by an industry is neither a necessary nor sufficient condition for the proper establishment of a cooperative research venture.

To help further get matters in perspective, we should note that the decline of U.S. post-World War II market dominance in many industrial areas was inevitable. First, the rapid rise of the international enterprise catalyzed the process. Second, the unprecedented open attitude of the U.S. government and the U.S. science establishment contributed materially to the international diffusion of scientific achievements. Third, the U.S. institutions of higher learning welcomed, even sought, students from around the world. Finally, of course, certain nations, most notably Japan, are able to concentrate disproportionate resources on exploiting scientific outcomes through market-oriented innovations because they have been and are significantly relieved of the necessity to pursue science on their own, given the openness of the U.S. research programs and results.

The U.S. benefitted materially from its science and technology transfer programs and activities for perhaps twenty or twenty-five years following the end of World War II. Moreover, we probably could have continued along this path without jeopardy but for two "failures" of our own policies, both public and private. First, the U.S. was increasingly wasting the resources necessary for research and development through the growing needless duplication of efforts, especially with regard to basic and applied research. This was due importantly, though not exclusively, to poorly thought-out antitrust attitudes and laws. Second, U.S. firms failed to acquire the rights to the technologies and techniques developed overseas on the basis of U.S. science, as a quid pro quo for the transfers.

But the stage is set for change. At last the U.S. is coming alive to at least some of the problems it faces with regard to U.S. competitiveness. One of the principal manifestations of this awareness is the mounting interest within both U.S. industry and government in cooperative research ventures. Properly constituted, such a venture is a joint activity which allows firms to share research results which they can then individually apply to new products, processes, and services for markets of their own choice. A cooperative research venture can obviously cut the costs of certain types of research and thereby free resources to expand the technological possibilities available to the participating firms and/or its licensees. It is this latter result which can have the most dramatic effect on progress -- measured both through gains in U.S. productivity and greater international competitiveness.

Avoiding the waste of R&D resources caused by the needless duplication of research is another common underpinning of cooperative research ventures. As earlier stressed, market competition should and must be preserved between firms participating in cooperative research ventures. But the preservation of such market competition does not require that each firm be encouraged to devote its independent and separate resources to every research task at hand. Generally, if the frontiers of science and technology which underlie an industry's products and services can be expanded more quickly and economically, those innovative and competitive products and services which generate both public and private benefits will emerge in profusion -- and do so more efficiently. In this connection, with regard to research outcomes, let me comment briefly about the Microelectronics and Computer Technology Corporation, MCC., the first of the new wave of cooperative research ventures. MCC was launched in 1981 and presently has 16 participating companies. Control Data is one of them and the benefits to us in terms of the availability of research results will be significant. More specifically, we have calculated that our commitment of $14,000,000 to several MCC research programs will give us over a three-year period access to research results of interest costing some $119,000,000. Not a bad bargain for us -- and for the nation considering other shareholders are gaining similar advantages.

Let me elaborate just a bit more on conversion of research outcomes into competitive products: cooperative research ventures in general should properly be confined to the research end of the process of innovation. The research results and technological possibilities emanating from research cooperation should be exploited by individual firms which carry out product development, production, and marketing in competitive rather than cooperative environments. The Japanese electronics industry has adopted this strategy with great success, to cite but one example.

The availability of the research results of cooperative research ventures is a crucial issue. And it has broad implications for both public and private policy. Cooperative research ventures certainly must make their research results available to participants in a timely, efficient manner. But, in my view, they should also be required to license such outcomes to others, after sponsors have enjoyed a suitable lead time (three years is about right for most industries) and, of course, such research results and technologies should command a fair price from non-participating licensees.

Equally important, cooperative research ventures should be encouraged to make a special effort to provide their research results to small enterprises. As will be emphasized more later, small business in the United States is an especially important source of innovations. This is not to say that large firms -- the sorts of entities primarily supporting cooperative research ventures -- are unnecessary to generate innovations. It is rather that small firms are critical to the maintenance of U.S. innovative performance across a broad industrial front.

Often, for example, the small enterprise can justify the earlier introduction of a new product or service because the potential returns relative to the size and investment of the firm are so much greater than is the case for its larger competitors. In this way, and others, the small business community provides long-run benefits to all who participate in such markets through the competitive spur it provides and the ever-improving products and services that result. Larger firms also benefit from the early testing of the market acceptance of innovations; they can then concentrate on improving the products which result and expanding the markets for them.

Importantly, because of its new-found interest in what is being referred to as "United States competitiveness," the federal government, including Congress, is showing mounting support for the encouragement -- rather than discouragement -- of cooperative research ventures. Such support is both timely and crucial to the establishment of pro-competitive research cooperation. At the present time, there are some half-dozen bills in Congress intended to encourage the formation of cooperative research ventures. While the approaches differ, all should be welcomed as reflecting a new vision on the part of the administration and of our national legislature.

UNIVERSITY-INDUSTRY-GOVERNMENT

A close linking of university, industry and government is, of course, another essential underpinning for expanding innovation -- both to more efficiently create and transfer new knowledge and to better train more people.

Critical U.S. shortages of scientific and technical personnel and inadequate laboratory facilities and instrumentation in universities, have all been well documented.

MEIS: An exemplary model of industry-university-government cooperation addressing these problems is the Microelectronics and Information Sciences Center at the University of Minnesota. The center founded in 1980 has an initial funding of six million dollars by industry and there will be more to follow. In addition, last year the State of Minnesota appropriated 1.3 million in funding, and the center is receiving federal research grants.

The center will greatly expand work/study programs by providing more instruction at work. Computer-based education will play an important role in helping to deliver instruction and administer examinations, thereby avoiding additional burdens on the faculty caused by the remoteness of the students from the university.

Even though a major part of the industry funding is provided by big business, another important and essential aspect of the program is that others, especially small enterprises, will have access to the results of the R&D. It is contemplated that many new companies will be spawned.

The final point to be made about the center is that there are strong beliefs by both industry and university participants that academic integrity and the cooperative advancement and application of technologies are compatible.

SMALL & LARGE COMPANY COOPERATION

In order to fully appreciate the enormous potential of greatly increased cooperation between large and small business, it is necessary to review a few more relevant factors about both.

First, small business is uniquely important in American society. It was the foundation on which our country was built and achieved greatness. It still is the primary means for encouraging and rewarding individual initiative. And it provides more products, services and jobs, relative to our GNP, than does small business in any other country.

Second, studies show that during the last decade small firms generated a high percentage of all new jobs; and third, small companies produce 24 times more innovations per dollar than larger ones, and they produce two and one-half times more innovation per employee than large companies.

Fourth -- we have a well developed securities market where equity capital can be raised by small entrepreneurs. It is unique to America.

And fifth, with respect to big business, is that in addition to the prodigious amounts of unused and underutilized technology in their laboratories, large companies have contingent assets in the form of underemployed management and professional personnel.

By making available its underused technology, and by offering its professional and management assistance to a small company, a large company can realize additional income from past investment. And, through equity investments in and R&D contracts with small companies, large companies can gain more economical access to new products and markets. Four years ago, my company started making equity investments in small companies, many of which are now developing products and services which will be marketed by Control Data. In fact, quite a few of those products and services were developed by the small companies using Control Data technology.

Such programs accentuate the strongest attributes of both large and small enterprise. To further elaborate on the advantages of small companies it should be noted that they are inherently more creative and flexible, with lower overhead. Hence, they can frequently develop new products and services sooner for less cost; whereas larger companies, with greater resources, can provide efficiencies in production and marketing.

The potential of cooperation between large and small business can hardly be overemphasized. Since this opportunity is not as readily available to other countries, we must capitalize on it, just as other countries, especially the Japanese, capitalize on the unique attributes of their culture.

But cooperation won't happen unless there is a widespread dedicated effort focused on that objective. In response to that need and the accompanying business opportunity, Control Data has developed numerous services to facilitate the process of large companies, universities and government laboratories working with small companies. At this time, I will only elaborate on two of them: Quest for Technology and Business & Technology Centers.

QFT: Quest for Technology, or QFT, as the name suggests, is a process to facilitate identification of technologies with commercial potential in the laboratories of business, academia and government. Quests are conducted by a team of professional and executive personnel from appropriate fields. Promising technologies are listed by Technotec, a data base of technologies available for commercialization or technologies wanted.

BTC: Our Business and Technology Centers provide various combinations of consulting services; shared laboratory, manufacturing and office facilities; and other services to facilitate the start-up and growth of small businesses. Economies of scale make it possible to provide occupants of the centers with needed facilities and services of much higher quality and considerably lower cost than any occupant would be capable of obtaining or providing for irself.

Control Data is also assisting small business by fostering public/private cooperation at the community level. More specifically, we are helping to launch and have been participating in the operation of community-based organizations with those objectives. I will describe two types: a cooperation office for small business and a seed capital fund.

CO: A cooperation office fosters the start-up and profitable growth of small businesses. It is a non-profit corporation financed during the early years by contributions and grants with the expectation that the organization will eventually become self-supporting from client fees and funds generated by investments in client companies.

A cooperation office's board of directors consists of leaders from all major sectors of society. The approach is simple: an entrepreneur has an idea for a new product or service and wants to start a company -- the cooperation office helps develop a business plan and obtain financing. The permanent staff is small, but the cooperation office draws on a volunteer advisory panel of engineers, scientists and executives for the specific expertise required to evaluate and help prepare the business plan. Because these plans are expertly conceived, the chances of receiving adequate financing and achieving economic viability are substantially increased.

Seed Capital Fund: Seed capital is often not available for new companies during their initial formation and early development stages from more conventional sources such as venture capital companies and banks.

Because of these realities, a seed capital fund is needed. The first one, the Minnesota Seed Capital Fund, was founded in 1979. It is receiving growing support. Recently, three pension funds became investors and several more are considering investment.

Job Creation Network: The cooperation office, the seed fund, and the BTC described a moment ago constitute what is called a network for job creation, which provides the support needed by small enterprises to become successful. Unfortunately, in our present economic system, such assistance is left too much to chance, with an undue burden on the entrepreneur. As a consequence, a high percentage of new businesses fail.

On the other hand, through expanded initiatives and cooperation among industry, government and universities, the necessary support can be provided to vastly increase the success rate for new enterprises. The network is being widely replicated.

STARCO: To stimulate the participation by business and industry in job creation, another program has also been devised called Start-a-Company. It has the objective of facilitating the process whereby well established companies assist in the startup of small enterprises. Assistance takes the form of technology spinoff, management and professional consulting, and/or equity investments.

The first program was launched in Minnesota last May. It is planned that larger companies in Minnesota will assist in the startup of two companies each and that smaller companies will assist in the startup of one company each. Thirty-three companies have committed to participate. Also, nine University of Minnesota senior faculty members have agreed to assist in identifying and transferring technologies to help get small companies started.

A final point to mention is that all types of companies can participate successfully, not just manufacturing companies, but also banks, insurance companies, retail companies, utilities, law firms, public accounting branch offices and so on.

Institutionalizing Innovation: There is one other function of a job creation network which merits mention -- it can help people to gain a better understanding of the critically important role of technology in society, especially the fact that most new jobs result from the application of technology by the process of innovation. Most people do not know where jobs originate, nor how terribly difficult it is to create them. That low level of understanding can easily accommodate the belief that the stork brings jobs; although in the U.S., the stork has been preoccupied with the more traditionally prescribed role.

A network in a community provides a perspective on job creation that can be widely understood because of local participation in the process. In other words, this is the way that the culture of technology must be implanted at the grass roots of society, because otherwise experience shows that most people won't become involved and assume their share of the responsibility for creating the jobs so badly needed.

LEGISLATION

Getting the necessary support for a job creation network is a long, hard process. In fact, financial incentives are needed to stimulate the required level of support. Last year

Minnesota passed legislation to encourage support for job creation networks. Briefly, it provides:

- a 50% tax credit for contributing to cooperation offices.
- a 30% tax credit for investments in new small companies, up to a maximum of $100,000.
- and a tax credit equal to 30% of the value of technology transferred by large companies to small businesses.

Let me elaborate on the reasons for these incentives. A major one is that, frankly, too many of our leaders in business, government, academia, foundations, labor and churches are simply unwilling or unable to face up to the seriousness of our problems -- too often it's everything as usual, with little inclination to accept the changes and commit to the effort necessary to make significant moves in new directions. As a consequence, the difficult process of job creation is often made even more difficult and takes twice as long as necessary. In some communities, it isn't even possible to get the cooperation and support required for an effective job creation program.

Almost five years have passed since the effort commenced to establish the first cooperation office in Minnesota. Raising the necessary funds was a challenging exercise. The concept was new and unemployment at that time in Minnesota wasn't nearly as high as it is today. Even after gaining acceptance of the merits, it was still necessary to overcome the barrier of established patterns for charitable contributions, which are very hard to change.

And, in spite of demonstrated success, it continues to be difficult to obtain adequate funding for the Minnesota Cooperation Office. Hence, the reason for the legislation granting a 50% tax credit for a contribution to a cooperation office or a similar type of organization. Incidentally, this same type of incentive is available in Pennsylvania and Indiana.

Establishing a seed capital fund is also difficult. Like a cooperation office, it requires dedication and arm twisting. Again this is reason for the Minnesota state tax credits for investments in new business startups.

Another problem is to convince executives in well-established businesses of the merits of assisting in the startup of small enterprises. Earlier, I mentioned that 33 companies are participating in the Start-a-Company program. On the surface, this appears good -- and, everything considered, it is --

except it has taken four years to gain the understanding necessary to get this level of participation, which has come about through urging their support for the cooperation office and the seed fund, and the track records of success which both are building. Hopefully, tax credits for technology transfer and investment will help stimulate more attention to the potential of cooperation with small businesses.

REGIONAL APPROACH

Now let me move from community cooperation to describe a regional approach for promoting technological cooperation among individual states and between those states and foreign countries.

A major objective of the approach is to establish a system which will foster increased technological cooperation and equitable technology exchange between a region of the U.S. and foreign countries. For reasons to be discussed later, Japan and Great Britain should be the first foreign countries targeted. Implementation can occur simultaneously and independently with each country.

Before providing a few highlights about the approach, I should also mention that the states which have been tentatively selected for a regional group are the members of the Midwest Governors Conference. A Steering Committee consisting of representatives from each of these states has been formed. It is chaired by Minnesota Governor Rudy Perpich. The Steering Committee will consider and recommend policies and the type of organizational structure to implement the program.

Japan: A major reason for selecting Japan for a regional program is simply that our federal government lacks the leadership and ability to achieve a consensus on solving the extremely serious problems in technology and trade with that country. A regional grouping of states in a public/private technology and trade consortium, however, can devise the necessary actions and marshall the support needed to effectively address them. Such a consortium could move faster and more flexibly than the U.S. as a whole, while bringing a critical mass to bear that no single state can achieve alone.

The most significant problem is that access by the United States to Japanese technology is pitifully small compared to the technology access that the U.S. provides to Japan. Research results from Japan are less accessible by other countries than from any other non-communist country. Most research in the U.S. is performed in universities and is accessible by other countries through the movement of graduate students, the widespread licensing of research results, and the practice of open publication of research results. In contrast, much of Japan's research is carried out in government laboratories and private companies whose laboratories are closed to American corporations. Thus, transfers of technology between the U.S. and Japan are heavily imbalanced in Japan's favor.

Furthermore, Japanese companies frequently obtain licenses for advanced technology developed in this country at low costs which inadequately reflect the cost of the technology, the risks assumed in its pursuit, or the time it takes to perfect it. This is particularly true of licenses obtained from universities and small companies.

In contrast to the open flow of low-priced technology from the U.S. to Japan, all advanced technology licenses flowing from Japan require approval by the Ministry of International Trade and Industry (MITI), which allows no bargains.

Cornerstones of the regional approach are equitable bilateral technology exchange, technological cooperation among states and between the region and Japan, and equitable bilateral trade agreements between the region and Japan.

Trade agreements normally should follow after technology exchanges and result from cooperative projects.

Cooperative projects should be selected which normally would not be undertaken by industrial firms because of high risk, long development cycle, or resource requirements too great for private sector funding. One area which comes to mind is the development of technology to recycle and/or dispose of toxic wastes. Other possibilities can be selected from such fields as energy, new materials and health care for the aging.

State and private sector funds would be used for financing cooperative technology projects and technology transfers.

Participation should be voluntary. The involvement of state governments would assure the cooperation of state universities. Large companies would find new opportunities for technological cooperation, and new markets for their products and services. Small companies would be able to improve their bargaining position in technology transactions to either establish or expand trading opportunities. For example, small concerns desiring to sell technology for cash rather than exchanging it for other technologies would have the option of selling to the consortium rather than Japan, thereby meeting their own cash-flow needs while enabling the consortium to get equitable technology in return.

"Value for value" would be the motto for the consortium. The surest method of achieving equity in the area of technology is simply to exchange it. That is, to import from Japan technology of a value equivalent to that exported.

Having outlined the essence of the regional approach and the reasons for selecting Japan as one of the initial partners, let me now review the two main reasons for selecting Great Britain as the other initial partner. One is that past studies have shown that Great Britain is second only to the U.S. in the number of technological possibilities, that are generated from its research and development effort. In contrast to its great creativity in generating technology however, Great Britain has consistently lacked the ability to exploit it through the complete process of innovation. On the other hand, the U.S. has a much better innovation record. Hence, the stage is set for a highly productive technological cooperation between the U.S. and Britain.

The second reason for choosing Great Britain is the similarity in culture between the two countries. Any broad-based cooperative program will be confronted with many problems, and cultural differences will tend to exacerbate them. Hence, progress is initially likely to be faster with Great Britain, where the differences are relatively minor, and this experience can be used to good effect in solving more difficult problems in a Japanese cooperative effort. However, aside from cultural differences, competition provides advantages to all parties.

The administration of a regional approach to technology and trade would not be easy; however, there is adequate experience to draw on to assure its success. The payoff will be the establishment of a system which will promote open, competitive and equitable conditions for technological cooperation and trade.

CONCLUSION

What the United States needs most of all is a surge of innovation on an unprecedented scale to improve productivity and create the new jobs so badly needed. The broad sweep of cooperation I have outlined is the centerpiece of such a program. It is do-able and affordable. Do-able because all parts, with the exception of the regional approach, are being successfully implemented today, albeit on too small a scale. Furthermore, there aren't any technical frontiers to break with the regional approach -- success depends primarily on dedication, and I believe there is a desire to do it.

And the program is affordable because its main thrust is to increase the efficiency with which we utilize present resources.

STATEMENT OF FRANK S. SWAIN, CHIEF COUNCIL FOR ADVOCACY, U.S. SMALL BUSINESS ADMINISTRATION

I appreciate the opportunity to comment on the crucial role small business plays in the states' high technology strategies, economic growth and job generation process.

Office of Advocacy

The Office of Advocacy was created within the Small Business Administration (SBA) under Public Law 94-305. As Chief Counsel for Advocacy, my responsibilities include representing the views and interests of small businesses before other Federal agencies. We are also statutorily mandated to develop a small business data base and to foster analytic information from which economic policy affecting small businesses may be developed. This data base can be used to examine job generation and economic growth within the states.

My statement will focus on the contribution which the high technology sector makes to employment growth. State economic development efforts to stimulate innovation and growth in high technology industries including incubator programs, Small Business Innovation Research (SBIR) and venture financing programs will also be discussed.

The High Technology Industries: Job generation and Small Businesses

The high technology industry is a fairly modest part of the national industrial base. It is not purely small or large business, but a mixture of various sized firms in different industries. High technology development is important from the standpoint of industrial innovation, quality of life and other factors, but it is not as important as many think from the perspective of job generation. High technology industries have and will continue to generate about ten percent of the new jobs in the country. Approximately 1.1 million of the 11.5 million jobs created during the period 1976 to 1980, were in the high technology sector.[1]

High Technology Definitions

There are wide variations in the definitions of what a high technology industry is. The popular perception is that high technology is synonymous with continuous innovation, but high technology industries are, in fact, engaged in marketing recently invented products. In reviewing definitions, a recent study concluded ". . . no empirical criteria are used to distinguish high technology from other industries."[2]

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[1] Catherine Armington, Candee Harris, and Marjorie Odle, "Formation and Growth in High Technology Businesses: A Regional Assessment" (Washington, D.C., prepared for National Science Foundation under Grant No. ISI 8212970 with additional analysis prepared for Office of Technology Administration, September 30, 1983). Original data development work was funded by SBA Contract No. 2641-OA-79; hereafter "Formation and Growth".

The most widely accepted formal definition, developed by the Bureau of Labor Statistics, equates high technology industries with knowledge-intensive manufacturing industries that employ larger numbers of engineers, scientists and technical workers than in manufacturing generally, and have a high level of research and development expenditures.[3] Recent research studies have broadened the scope of this definition to also include service industries that meet these criteria. Under this formal definition, most high technology industries are dominated by large businesses since it is large firms, with 500 or more workers each, that employ 94 percent of U.S. scientists and engineers, and that account for 96 percent of R&D expenditures, including both companies' own and federal funds.[4]

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[2] Marjorie Odle, "High Technology vs High Growth Industries," talk delivered at Small Business Research Conference, Bentley, Massachusetts, March 1983.

[3] See, for example, Richard Riche, Daniel E. Hecker, and John U. Burgan, "High Technology Today and Tomorrow: A Small Slice of the Employment Pie," Monthly Labor Review, November 1983, pp. 50-59.

[4] "Trends in Small Companies' R&D Expenditures," report prepared by the National Science Foundation (Washington, D.C.: National Science Foundation, June 1984).

Although these industries are receiving a substantial amount of attention, they are actually a very small component of the United States' industrial base. Only 2 percent of the business establishments in the U.S. are in high technology industries. They account for slightly more than 7 percent of all private sector employment.[5] Within the manufacturing sector, high technology industries represent 11 percent of business establishments and 21 percent of manufacturing employment.

In spite of this limited economic role, the new employment opportunities generated by these industries and the increasing dispersion of new technologies have focused attention on them.

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[5] "Formation and Growth," p. iii.

According to estimates developed by Advocacy's Office of Economic Research, there are 31,000 small businesses each with less than 100 employees in the high-technology industry groups. In total, these groups (three-digit SIC level) account for 34,000 business enterprises.

Employment Growth in High Technology Industries

High technology employment grew by 19.4 percent from 1976 to 1980 while non-high technology manufacturing employment expanded by only 6 percent.[6] Research developed for the U.S. Small Business Administration, Office of Advocacy utilizing the Small Business Data Base found that:

- "Growth rates in the high technology sector were 66 percent higher than in low technology industries, but the small size of the sector limits its current contribution to net job creation (about 1.1 million of the 11.5 million jobs created between 1976 and 1980).

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[6] Candee S. Harris, " High Technology Entrepreneurship in Metropolitan Areas," forthcoming publication in Local Economic Development: Issues and Initiatives, edited by Edward Bergman (Durham, N.D.: Duke University Press, 1984); hereafter "High Technology Entrepreneurship."

- Within the high technology sector, employment growth rates vary widely across (the 88) industries. Despite high average growth rates for the sector, almost one-fourth of the high technology industries experienced net losses of employment between 1976 and 1980.

- A region's high technology growth is largely a reflection of its overall economic performance.

- There appears to be a redistributive effect in that those regions with the smallest share of high technology employment experienced higher growth rates.

- Growth depends primarily on business formations: a region tends to capture approximately the same share of formations in each industry sector."[7]

Small Firms in High Technology Industries

Across the 88 high technology industries studied by Harris, small independent firms grew in employment and "independent firms in all industrial sectors had much higher growth rates than affiliates of larger firms between 1976 and 1980."[8]

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[7] "Formation and Growth," p. 81 & 82.

[8] "High Technology Entrepreneurship," p. 4.

This is particularly noteworthy because the proportion of employment held by small businesses is mixed (see Table 1). The greatest share of employment by small firms, with less than 100 workers each, is found in the industrial patterns industry (SIC 3565) where 9,756 jobs or 92.5 percent of the employment is in small firms. At the low end of the spectrum, only 0.3 percent or 1,424 jobs out of the 474,631 in aircraft (SIC 3721) are in small businesses.

Yet, even in the large business dominated high technology industries where employment has declined, small firms are consistently generating jobs. To illustrate the performance of the small business component, employment data for ten high technology industries is presented by firm size in Table 2 on the "1976-82 Employment Growth by Firm Size in Selected High Technology Industries." This table shows the small firm contribution in terms of the absolute numbers of jobs and in percentage terms.

Although the industries shown were selected at random, there is a pattern of particularly high employment growth rates in the smallest size category of firms. In each of the industries, small businesses with 0-19 workers were generating jobs at rates substantially greater than the average growth rate for the industry.

TABLE 1
Number of Employees for Selected High Technology Industries, 1980

SIC Code	Industry	Employment < 100	Employment Total	Percent In Small Businesses	Rank
	Total	757,981	9,444,114	8.0%	
2812	Alkalines & Chlorine	652	90,172	1.7%	[illegible]
2813	Industrial Gases	1,652	35,138	4.7%	[illegible]
2816	Inorganic Pigments	1,834	6,217	29.5%	[illegible]
2819	Industrial Inorganice Chemical, n.e.c.	11,788	222,419	5.3%	[illegible]
2821	Plastic Materials, Syn. Resins	10,399	148,551	7.0%	[illegible]
2822	Synthetic Rubber	2,181	7,197	30.3%	[illegible]
2823	Cellulosic Man-Made Fiber	508	46,217	1.1%	[illegible]
2824	Synthetic Organic Fibers, except Cellulosic	838	139,617	0.6%	[illegible]
2831	Biological Products	3,128	6,397	48.9%	[illegible]
2833	Medical Chemical Botanical Products	4,013	60,796	6.6%	[illegible]
2834	Pharmaceutical Preparations	10,135	506,767	2.0%	[illegible]
2841	Soap, Other Detergents	6,055	151,626	4.0%	[illegible]
2842	Special Cleaning, Polishing Preparations	16,548	73,874	22.4%	[illegible]
2843	Surface Active Finishing Agents	1,739	3,410	51.0%	4
2844	Perfumes, Cosmetics, Toilet Preparations	10,404	139,781	7.5%	[illegible]
2851	Paints, Varnishes, Lacquers, Enamel	21,482	121,384	17.7%	[illegible]
2861	Gum, Wood Chemicals	1,090	11,609	9.4%	[illegible]
2865	Cyclic Crude, Intermediates, Dyes	2,004	44,528	4.5%	[illegible]
2869	Industrial Organic Chemical, n.e.c.	6,454	239,653	2.7%	[illegible]
2873	Nitrogenous Fertilizers	3,677	22,897	16.1%	[illegible]
2874	Phosphate Fertilizers	1,329	19,540	6.8%	[illegible]
2875	Fertilizers, Mixing Only	3,500	7,867	46.7%	[illegible]
2879	Pesticides, Agriculture Chemical, n.e.c.	4,645	22,550	20.6%	31
2891	Adhesives, Sealants	8,055	18,646	43.2%	[illegible]
2892	Explosives	529	2,351	22.5%	[illegible]
2893	Printing Ink	3,305	12,577	26.7%	[illegible]
2899	Chemical, Chemical Preparations, n.e.c.	16,445	85,650	19.2%	[illegible]
2911	Petroleum Refining	4,754	250,204	1.9%	[illegible]
3031	Reclaimed Rubber	651	3,115	20.9%	[illegible]
3482	Small Arms Ammunition	9,056	62,892	14.6%	[illegible]
3483	Ammunition, except Small Arms, n.e.c.	339	7,711	4.4%	[illegible]
3484	Small Arms	1,988	11,427	17.4%	[illegible]
3489	Orders, Accessories, n.e.c.	745	5,285	14.1%	47
3511	Steam, Gas, Hydraulic Turbines	1,487	78,241	1.9%	[illegible]
3519	Internal Combustion Engines, n.e.c.	2,232	131,279	1.7%	[illegible]
3531	Construction Machinery Equipment	12,248	170,115	7.2%	61
3532	Mining Machinery Equipment	5,149	74,617	6.9%	63
3533	Oil Field Machinery Equipment	9,718	198,332	4.9%	71
3534	Elevators, Moving Stairways	2,991	20,726	12.9%	[illegible]
3535	Conveyers, Conveying Equipment	10,536	33,662	31.3%	[illegible]
3536	Hoists, Industrial Cranes, Monorial Systems	4,054	20,472	19.8%	[illegible]
3537	Industrial, Truck., Tractors, Trailer Stackers	8,290	50,547	16.4%	[illegible]
3541	Machine Tools, Metal Cutting Types	20,986	98,525	21.3%	[illegible]
3542	Machine Tools, Metal Forming Types	7,881	34,871	22.6%	[illegible]
3544	Special Dies, Tool Sets, Jigs & Fixtures	89,841	119,637	75.1%	[illegible]
3545	Machine Tools Accessories, Measurement Devices	29,380	73,633	39.9%	[illegible]
3546	Power Driven Hand Tools	2,386	40,232	5.9%	[illegible]
3547	Rolling Mill Machine Equipment	1,051	5,441	19.3%	[illegible]
3549	Metalworking Machinery, n.e.c.	5,566	23,992	23.2%	[illegible]
3561	Pumps, Pumping Equipment	7,750	33,843	22.9%	[illegible]
3562	Ball, Roller Bearing	1,806	55,121	3.4%	77
3563	Air, Gas Compressors	2,837	18,541	15.3%	[illegible]
3564	Blowers, Exhaust, Ventilation Fans	8,644	64,507	13.4%	[illegible]
3565	Industrial Patterns	9,756	10,587	92.2%	1
3566	Speed Changers, Drives, & gears	4,197	36,492	11.5%	[illegible]
3567	Industrial Process Furnaces, Ovens	7,325	30,261	24.2%	[illegible]
3568	Mechanical Power Transmission Equipment, n.e.c.	1,525	28,202	5.4%	[illegible]
3569	General Industrial Machinery Equipment, n.e.c.	24,052	95,826	25.1%	[illegible]
3573	Electronic Computer Equipment	16,057	1,003,561	1.6%	[illegible]
3574	Calculators, Accounting Machinery, except electrical computer equipment	653	72,522	0.9%	93
3576	Scales, Balances, except laboratory	1,475	8,328	17.7%	[illegible]
3579	Office Machines, n.e.c.	2,705	87,257	3.1%	[illegible]
3612	Power, Distributors Special Transforms	6,213	477,929	1.3%	[illegible]
3613	Switchgear, Switchboard Apparatus	7,728	45,436	17.0%	[illegible]
3621	Motors, Generators	5,673	126,078	4.5%	[illegible]
3622	Industrial Controls	11,890	205,888	5.8%	67
3623	Welding Apparatus, Electric	3,369	18,312	18.4%	[illegible]
3624	Carbon, Graphite Products	902	9,601	9.3%	[illegible]
3629	Electric Industrial Apparatus, n.e.c.	3,638	6,662	54.6%	3

Number of Employees For Selected High Technology Industries, 1980

SIC Code	Industry	Employment < 100	Employment Total	Percent In Small Businesses	Rank
		78			
3651	Radio, TV receiver sets, except communication types	9,571	281,491	3.4%	78
3652	Phono Records, Pre-Recorded Magnetic Tapes	8,055	28,864	27.9%	17
3661	Telephone, Telegraph Apparatus	5,019	43,642	11.5%	54
3662	Radio, TV Transmit, Signal, Dectective Equipment	34,855	683,432	5.1%	[illegible]
3671	Cathode Ray Tubes, n.e.c.	259	1,695	15.3%	[illegible]
3674	Semiconductors, Related Devices	17,073	200,853	8.5%	[illegible]
3675	Electronic Capacitors	1,005	11,046	9.1%	[illegible]
3676	Resistors for Electronic Apparatus	1,113	4,598	24.2%	22
3677	Resistors, Electric Apparatus	4,035	14,058	28.7%	15
3678	Connectors, Electric Apparatus	841	24,747	3.4%	[illegible]
3679	Electronic Components, n.e.c.	55,060	214,241	25.7%	[illegible]
3721	Aircraft	1,424	474,631	0.3%	[illegible]
3724	Aircraft Engines, Parts	3,720	218,803	1.7%	[illegible]
3743	Railroad Equipment	1,859 1,877	88,550 32,722	2.1%	83
3761	Guided Missiles, Space Vehicles	256	36,666	0.7%	84
3769	Guided Missiles, Space Vehicles Parts, n.e.c.	290	669	43.3%	7
3811	Engine, Laboratory, Scientific, Research Institutions	12,375	65,478	18.9%	[illegible]
3822	Environmental Applications	6,046	51,677	11.7%	[illegible]
3823	Industrial Instrument Measure Display	12,833	61,697	20.8%	[illegible]
3824	Fluid Meters, Counting Devices	2,247	12,279	18.3%	37
3825	Instrument Measuring, Testing Electrical Devices	9,709	80,242	12.1%	51
3829	Measuring, Controlling Devices, n.e.c.	8,416	25,123	33.5%	11
3832	Optical Instruments, Lenses	8,469	29,716	28.5%	16
3841	Surgical, Medical Instrument Apparatus	14,439	117,386	12.3%	50
3842	Orthopedic, Prosthetic Surgical Applications	10,063	100,626	10.0%	[illegible]
3843	Dental Equipment, Supplies	6,218	18,343	33.9%	10
3861	Photographic Equipment, Supplies	11,216	400,552	2.8%	81

Note: The definition of high technology industries is from Amy K. Glasmeier, Peter G. Hall and Ann R. Markusen, "Recent Evidence on High Technology Industries' Spatial Tendencies: A Preliminary Investigation." Prepared for the National Science Foundation and Office of Technology Assessment, draft, October 1983.

Source: U.S. Small Business Administration, Small Base Data Base, 1980, unpublished data.

TABLE 2

1976-82 Employment Growth by Firm Size in Selected High Technology Industries

SIC Code	Type of Industry	Total Number Of Employees 1976	Employment Change by Firm Size, Number & (Percent) Total	0-19	20-99	500+	Employment Share in Small Firms with <100 Employees Percent
	High Growth, Small Business Dominated						
3544	Special Dies, Tool Sets, Jigs & Fixtures	130,356	13,649 (10.5)	15,807 (40.7)	2,383 (5.2)	-5,325 (-21.1)	75.1
7394	Equipment Rental & Leasing Services	221,295	75,014 (33.9)	53,682 (47.4)	2,502 (5.4)	17,753 (50.8)	70.7
7399	Business Services, n.e.c.	471,391	195,800 (41.5)	83,687 (51.3)	23,816 (31.1)	73,653 (42.9)	64.5
	High Growth, Large Business-Dominated						
2911	Petroleum Refining	158,255	26,955 (17.0)	1,118 (96.9)	2,587 (96.2)	19,398 (12.9)	1.9
3535	Conveyers, Conveying Equipment	41,625	3,747 (9.0)	1,924 (63.3)	2,727 (35.8)	-2,050 (-9.3)	31.3
3568	Mechanical Power Transmission Equipment, n.e.c.	16,452	2,367 (14.4)	307 (58.5)	314 (33.0)	824 (6.1)	5.4
3823	Industrial Instrument	78,822	24,887 (31.6)	5,633 (139.8)	5,017 (89.9)	10,629 (17.5)	20.8
	Negative Growth, Large Business-Dominated						
2823	Cellulosic Man-Made Fiber	20,640	-2,363 (-11.5)	92 (101.1)	17 (3.6)	-2,431 (-12.3)	1.1
3651	Radio and TV Receiver Sets	117,412	-852 (-0.7)	1,560 (51.7)	792 (14.4)	-6,592 (-6.6)	3.4
3675	Electronic Capacitors	31,871	-16,351 (-51.3)	208 (140.5)	450 (133.9)	-1,776 (-62.7)	9.1

Note: SBA's Office of Advocacy defines an industry as small business-dominated when 60 percent or more of the industry's employment is found in businesses with fewer than 500 employees; an industry is large business-dominated when 60 percent or more of the industry's employment is in firms with at least 500 workers.

Source: U.S. Small Business Administration, Office of Advocacy, Small Business Data Base, unpublished data.

State Experimentation in High Technology Development Incubators

In order to facilitate business growth and thereby stimulate job generation, several states have developed a variety of specific programs focusing on start-up firms which are primarily small businesses. Some target high tech firms while others are more broadly structured.

One approach that cities, counties, public and private firms and universities are undertaking is to start small business incubators. Incubators encourage entrepreneurship and minimize obstacles to new business formation and growth, particularly for high technology firms, by housing in one facility a number of fledgling enterprises which share an array of services. These shared services may include reception and meeting areas; secretarial services such as collation, telephone answering, and mail handling; accounting and bookkeeping; research library; on-site financial and management counseling; parking; flexibile lease arrangements; and computer word processing facilities.

From a public policy perspective, job creation and retention are usually the primary goals of incubator programs that use public monies. A successful incubator program can mean an expanded tax base for a community through new business revenues and personal incomes. In addition, many incubator programs have begun to revitalize decaying neighborhoods by rehabilitating old or vacant buildings.

Business incubators have existed in some form or another for over two decades, but only recently have they received national attention. Since 1978, about 50 incubators have been established.

For example, North Carolina, under the auspices of the Technological Development Authority administers an incubator facilities program. The incubator facilities are intended to be community projects drawing on the resources of local colleges and universities, business and financial communities and the public sector. Localities may apply to the Authority for one-time grants of up to $200,000 per facility. However, these grants must be at least equally matched in cash or real estate. Incubator facilities and any improvements must be owned by the state.

In the State of Kansas, H. B. 2652 provides for the establishment of one or more incubator facilities within the state, and authorizes the state's Secretary for Economic Development to select sites for the facilities using the following criteria:

1. unemployment rate
2. the need for industrial and economic diversification and development; and
3. the interest by the localities in the establishment of a facility.

The Secretary can also make one-time grants, in an amount not to exceed $50,000, to non-profit corporations associated with community industrial development committees to establish the facilities. These grants must be matched in cash or real estate value by local government units or other interests.

Several other states have either proposed or enacted legislation providing for the development of incubator facilities. These include Michigan, Kentucky, Massachusetts, Mississippi, Pennsylvania and West Virginia.

Universities involved in incubators have done so because the facilities could potentially become the seeds for a new high technology economic base for the surrounding areas.

One example is the Rensselaer Polytechnic Institutes (RPI) incubator, known as "Building J." This old building houses thirteen businesses in a unique incubator program that gives start-up firms cheap, office space, access to university resources such as faculty members and computer time, and management and financial assistance. Some of the founders and executives of the companies are RPI faculty and staff. The University administration believes that the environment of Building J has many advantages beyond giving fledging companies a better than average chance for a successful start. The companies serve as business laboratories for RPI students trained more as engineers than entrepreneurs and also provide potential tenants for a new 1,200 acre RPI owned industrial/technology park.

This 3 year old program has hatched at least one successful company---Roster Technology, Inc., a fast growing computer graphics company which was formed by RPI graduate students in 1981. The company moved to Boston's Rt. 128 high tech area once it became successful. However, other companies are getting ready to leave the program and settle in surrounding areas in the state. The companies that populate Building J run the high tech gamut. So far the program has not had one failure.

With the success of the incubator program, RPI officials say they have been contacted by a large number of universities interested in setting up their own similar programs. According to the facility managers "the incubator program has made a profound statement across the country about what a university can do to foster innovation and help entrepreneurs."

Private developers have also seen the advantage of applying the incubator concept to joint ventures and other related activities in which they have a vested interest, most notably Control Data Corporation in Minneapolis, Minnesota. Since 1979, Control Data has established business and technology centers in 10 cities. These centers provide entrepreneurs in technology-oriented industry with a broad range of professional services and cost-effective space.

Some incubators target high tech firms and others hope to attract labor-intensive industries. Privately financed incubators typically look for high growth companies with good investment potential, while the publically funded projects have economic revitalization goals.

In summary, a conducive business climate, an adequate small business formation rate, and a potential for strong alliances between the public and private sectors are the necessary ingredients for successful incubators projects. There is adequate evidence that these ingredients exist in both large and small communities throughout the United States.

SBA's Private Sector Initiatives office is encouraging the formation of incubator programs by bringing together individuals, organizations, and various levels of government interested in sponsoring incubator facilities. The office assists incubator sponsors in refining their financial and administrative plans, and helps locate financing from both the private and public sectors. In addition, the office collaborates with SBA's Management Assistance Office to provide counseling and advice to firms in the facilities.

Small Business Innovation Research Programs

The SBA also coordinates and monitors the overall activities of twelve Federal agencies participatiing in the Small Business Innovation Research (SBIR) program. Under the Small Business Innovation Development Act, P.L. 97-219, small, high-technology firms must get at least a minimum share of research and development (R&D) awards made by Federal Agencies.

There are three phases of an R&D award in the SBIR program:

Phase I Generally $50,000 or less for research projects to evaluate the scientific and technical merit and feasibility of an idea.

Phase II Awards of $500,000 or less will made to further develop projects exhibiting the most potential as a result of Phase I funding.

Phase III At this stage, private-sector investment and support is relied upon to bring an innovation to the marketplace. When appropriate, this phase may also involve follow-on production contracts with a federal agency for future use by the Federal Government.

Although quite diverse, the states have generally modeled their local SBIR programs after the Federal program in an effort to attract high tech businesses, provide assistance to start-ups, and help existing firms to expand.

For example, Utah's SBIR program, handled through the Department of Community and Economic Development, is designed to help Utah small high tech firms gain more of the Federal

SBIR program grants and to comply with the Federal criteria established for Phase I, Phase II, and Phase III funding. The program provides funding between the first two phases of the Federal program in order to allow businesses to sustain operations and develop their products during this possible funding gap. It may also provide some of the Phase III financing for very promising business products.

In Pennsylvania, the Ben Franklin Partnership Fund, also patterned after the Federal SBIR program for small business research, was designed to: help small and start-up businesses in the research and development phase of their businesses; further develop or introduce advanced technology into the marketplace; strengthen the technological position of Pennsylvania's economic base; and, create new sources of employment through an increase in the commercial application of research results. The state also has a "Seed Grant" program which can provide up to $35,000 to entrepreneurs who can meet the established criteria.

The North Carolina SBIR program is administered by the Small Businesses Assistance Division of the State Department of Commerce. The program is designed to increase R&D opportunities in the state for high tech firms and to raise the awareness of Federal R&D opportunities. The state provides some financial and technical assistance to qualified firms.

Other ways in which the states are addressing the early stage financing needs of small, high-tech firms are discussed in the next section on venture financing programs.

State Venture Capital and Early-Stage Financing Strategies

Several states have recently developed venture and early-stage financing programs to foster new business formation and innovation. By the end of 1983, states had invested over $300 million in venture financings, not including tax credit programs. This compares to the private venture industry which has a capital pool of over $12 billion outstanding.[9]

Over the years, many states found that the private venture industry, while offering an important contribution to economic development, often invests in too few regions and industries to meet their diverse needs. For example, in 1983 sixty-nine percent of private venture dollars was invested in four states, California, Massachusetts, Texas and New York, and sixty-seven percent of the companies were in computer hardware and systems, software and services, telephone and data communications and other electronics industries.[10] Conversely, the states target their venture financing programs to meet individual economic development needs and the needs of local innovative businesses which may or may not be categorized as high technology firms.

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[9] Capital Publishing Corporation, "Venture Capital Journal," July 1984, p.4.

State-initiated venture programs exist in less than half the states. They are generally still in an experimental stage with funding levels for individual programs typically less than $10 million. States such as Connecticut, Indiana, Iowa, Louisiana, Massachusetts, New Mexico, New York and Wisconsin offer more than one type of venture financing vehicle, one or more of which is usually high technology-specific. The number of transactions funded are typically under 20 deals per year. However, such low volume is also typical of private venture firms.

Underwriting Standards

State-initiated venture programs, particularly those which are independently operated and privately capitalized, will generally use private venture standards as their guide. Private venture capital firms and state programs expect to participate to some degree in the management of nearly every venture they back.

A substantial investment by the entrepreneur is almost always necessary, if not in money then in time and energy. Financing is typically provided to relatively small, new and existing firms exhibiting above-average growth rates, a significant potential for market expansion and in need of additional financing for sustained or new growth or further research and development. Other factors weighing the venture investment decision include: the competition, the uniqueness of the product and the distribution patterns.

The type of instruments which may be used include: equity, debt or some combination of both offered through convertible debentures or debt with warrants and stock options. The convertible debenture is a hybrid debt/equity financial instrument employed to gain the fullest participation in the rewards of ownership, while also permitting effective control.

The state program administrators generally indicate a willingness to co-invest with private venture firms or other types of financial institutions depending upon the requirements of each transaction, i.e., necessary industry expertise, total capital needs and riskiness.

For some state programs, the method of realizing a return on the investment can be different from that of a private venture firm. The private venture firm must ultimately dispose of its investment to realize its return and recover principal. Normally this occurs either through a public offering of stock or the outright sale of the company whichever makes more sense at the time. Other options could include the venture capital firm establishing a contractual right to "put" the sale of its position to the principals at a predetermined ratio (i.e., 5 times earnings). Whereas, several state programs allow for a more flexible method of return. For example, in New Mexico repayment occurs only if the business is successful; then the business must repay to the state general fund 2 percent of gross sales for 8 years up to a maximum of three times R&D contract investment.

Structure/Form of State Programs

Following is a discussion of state venture financing vehicles which often have a high technology focus: pension fund initiatives, tax credit incentives, research and development grant and royalty programs other than SBIR's and state chartered capital firms.

Pension Funds:

Rapidly growing state and local government pension (or retirement system) funds provide a unique source of capital to all economic sectors, particularly for new or expanding business financing needs. In recent years, states have begun expanding their pension funds' list of legal investments to allow for higher returns and alternative investments including small business and venture capital financings--usually in limited amounts of up to two percent to five percent of assets.

In the case of the Ohio Public Employees Retirement System (PERS), up to five percent of its assets or $350 million are set aside for equity investments. Four transactions for approximately $55 million were funded through existing internal management. The remainder of the targeted funds are being privately managed by a venture capital fund which utilizes similar restrictions and return objectives. PERS is limited to investing its venture funds in companies which are: 1) headquartered in Ohio, or 2) have 50 percent of their assets in Ohio, or 3) have 50 percent of their employees in Ohio. The types of fundings have been diverse, including leveraged buy-outs as well as fundings at three stages of growth: start-up; second-round; and expansion financing.

The Washington State Retirement System participates as a limited partner in several private venture capital partnerships, concentrating on investments in high technology industries and computer-oriented transactions. The desired rate of return on investments is at least 25 percent per annum. With no geographic designations or limitations, by year-end 1983, over $6 million had been invested.

Tax Incentives:

In the states where 100 percent private financing is preferred for the publicly-chartered corporations, tax credits appear to be the most attractive method to reach private investors. Montana Capital Companies, still in organization, will be privately owned and operated venture firms, capitalized and organized by private citizens who in turn qualify for a 25 percent tax credit on Montana State taxes, subject to a total tax credit availability of $1.5 million. To date, two capital companies have been approved; Investors receive a 25 percent state tax credit in return for their investment in these companies which must reside in Montana.

Indiana established its Corporation for Innovation Development under 1981 legislation as a for-profit, privately owned and operated venture firm. Seventy-three investors bought shares totaling $10 million in return for a 30 percent state tax credit. CID was created to overcome the capital shortfall in the state, create a more attractive environment for businesses, and encourage the development of innovative new businesses from within the state rather than attempting to attract firms from outside the state. The Corporation has raised $10 million from individuals and corporations.

Research and Development Grant and Royalty Agreements

States offer an assortment of research and development equity or grant programs in addition to SBIR-modeled programs.

The uniqueness in New Mexico's program lies in its funding of research and development contacts. Under 1983 legislation, the New Mexico Energy Research and Development Institute (NMERDI) was designed to provide research and development assistance to private sector entrepreneurs or existing businesses conducting research in energy related industries. R & D contracts are designed to bring products to commercialization in a maximum of two to three years. As stated earlier, repayment, if any only occurs if the business is successful and then up to 2 percent of gross sales up to a maximum of three times of the contract. If the business moves out of New Mexico, the repayment is 5 percent of gross. NMERDI receives its annual funding from the state's severance tax, (oil, gas, uranium taxes) income fund. NMERDI's program objective is to create a job in the state for less than $5,000.

The Connecticut Product Development Corporation targets its program to financing the research and development stage of firms. In return, CPDC receives royalty payments as a percent of sales. Since its initial funding in early 1970's of $300,000 and $6 million in general obligation funds, CPDC has funded the creation of approximately 700 jobs. In 1983, the legislature subsequently increased funding levels to $11 millions and separately approved $2 million for high technology new product development.

In Indiana, the nonprofit Corporation for Science and Technology was established by the Indiana legislature in 1982 to provide: grants to universities for research determined to aid in the economic development of the state; seed money for the organization and implementation of one or more industrial institutes; research park development; and research programs in conjunction with the National Science Foundation and/or other federal agencies.

Other states which provide research and development funding include Wisconsin and Iowa.

Publicly Chartered Corporations

State-chartered corporations that specialize in early stage or seed capital funding for new, start-up and/or existing innovative small business enterprises are a relatively recent phenomenon. In return for tax and/or regulatory relief, these corporations appeal to financial institutions and private investors for capitalization. The programs and structure of the corporations can be quite varied: for-profit; nonprofit;

private or publicly funded and managed; or some variation of public-private co-investment. Often with minimum public intervention and public funding, these corporations will achieve public policy objectives of inducing small business development, while simultaneously maintaining or creating new jobs and generating new tax revenues. Because of their newness, however, cost effectiveness and return on investment is indeterminable (i.e., Indiana 1981, Montana 1983, Louisiana 1981, and Utah 1983).

The Utah Technology Finance Corporation (UTFC) is in the process of developing a venture capital fund which will be privately managed and capitalized by $1 million from the state and $4 million from private investors. The program is still in the developmental stages; however, UTFC will target its efforts towards technologically innovative small business.

The Massachusetts Technology Development Corporation, an independently operated, nonprofit venture capital firm, has been highly successful in providing venture capital to otherwise overlooked ventures, and has come to be a model for similar initiatives in many other states. MTDC helps new high technology companies and inventors achieve commercial success by providing debt, equity, or royalty arrangements. Initially capitalized with both state and federal funds of $5 million, MTDC has invested in over 17 start-up or early stage companies since its inception.

Other Financings

The California Innovation Development Loan Program (CIDP) was created in 1981 with a $2 million EDA grant and $2 million state appropriation. CIDP provides management, technical, and financial assistance to innovators and small businesses engaged in the production of new, innovative products or services who have had difficulty finding funding from other more traditional sources. Some start-ups have been funded but companies must begin repayment immediately.

The Illinois Venture Investment Fund was established to finance new product development at the pre-prototype stage as an outgrowth of the Governor's Task Force recommendations on high technology development.

Advocacy Research

In a report developed by my Office entitled, "State Activities in Venture Capital, Early-Stage Financing, and Secondary Markets," we summarized state financing strategies which meet the start-up and expansion needs of young firms. A copy of this report is attached.

Some of the findings regarding state venture capital or early stage financing programs are as follows:

1. Very few state initiated venture programs exist relative to state guarantee or industrial development bond programs.

2. The ideal program is different for every state depending upon economic conditions, business community, type of industries, universities, private venture capital flows, etc.

3. Direct or state entity investment in firms may be forbidden by state constitution or statute.

4. State governments lack the expertise to become effective investors by themselves. The programs often flounder or never get off the ground unless professional venture capitalists are hired or financings are undertaken with experienced venture firms.

5. Management and technical assistance is rarely provided as an adjunct service; but typically is needed both before and after the firm secures the financing.

6. Funds are seldom allocated to these programs to educate businesses as to the availability of funds and how to qualify for financing.

Conclusion

States are attempting a variety of projects to provide an environment more conducive to the growth of the high technology industries such as electronics, telecommunications, medical equipment, research and development, and aerospace. As important as these efforts are, the number of jobs in high technology industries is not as great as is often imagined and state policymakers should not look to high technology companies alone for short-term job growth. However, state efforts to foster high technology development are important to economic growth and small firms play a key role in this growth. To the extent that a state's primary goal is to increase employment, it is important to bear in mind where high tech job growth came from. Not all high tech industries show job growth in recent years, although even where a high tech industry has shown overall job loss, employment in small firms is often increasing nevertheless. These employment patterns strongly suggest that concern for high tech jobs ought to focus on small business development. The reduction of financial, regulatory, and economic barriers to small firm formation and growth are critical to the success of state high technology industry development efforts.